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new southern sky

National Airspace and Air Navigation Plan

Modernising New Zealand's Aviation System

CAA
CIVIL AVIATION AUTHORITY OF NEW ZEALAND

Contact details

Civil Aviation Authority of New Zealand
Level 15, 55 Featherston Street
P O Box 3555, Wellington 6140, New Zealand.

T +64 4 560 9400
F +64 4 560 2024
E info@caa.govt.nz

www.caa.govt.nz

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Foreword

From small beginnings, New Zealand's aviation sector has grown rapidly to become a critical part of our transport system. We rely on aviation to do business and to connect with our families and friends. Aviation has a vital role in supporting the tourism sector, with more than 99 percent of our international visitors arriving by air, and many of those visitors going on to explore New Zealand by air.

Although there have been significant advances in aircraft technology, like much of the world, New Zealand still relies on post World War II technology in many supporting aviation systems including navigation, surveillance, communications, air traffic control and information.

The National Airspace and Air Navigation Plan sets a pathway to modernise all aspects of our aviation system and position it for the future. Modernisation of the aviation system will bring huge benefits – valued at $2 billion over 20 years as a result of shorter and more efficient flight paths, and improved safety and reliability.

One of the most significant aspects of The National Airspace and Air Navigation Plan is the proposed move from land-based systems to space-based satellite navigation and surveillance. These changes will require new systems to be installed both on the ground and in aircraft. The National Airspace and Air Navigation Plan contains provisions to make sure that the transition to these new systems occurs smoothly, and that appropriate contingency systems remain to ensure resilience.

I would like to acknowledge the constructive role that the aviation sector has played in developing The National Airspace and Air Navigation Plan. As the government delivers on the initiatives outlined in this Plan there will be more opportunities for the sector to play its part in this significant transition.

Over the next 10 years, the Civil Aviation Authority will lead a challenging programme to implement The National Airspace and Air Navigation Plan. This ongoing programme to modernise our aviation system will be referred to as "New Southern Sky".

The government will continue to work closely with the aviation community on the delivery of the programme. This way New Zealand will realise the social, environmental and economic benefits of a safe, secure and modern aviation system now and well into the future.

Hon Gerry Brownlee
Minister of Transport

Contents

Abbreviations

AC	Advisory Circular
ACARS	Aircraft communication addressing and reporting system
ACAS	Airborne collision avoidance system
ACDM	Airport collaborative decision making
ACO	Airline control operation
ADS-B	Automatic dependent surveillance - broadcast
ADS-C	Automatic dependent surveillance - contract
AeroMACS	Aerodrome mobile airport communication system
AFTN	Aeronautical fixed telecommunication network
AIC	Aeronautical information circular
AIP	Aeronautical information publication
AIS	Aeronautical information services
AIXM	Aeronautical information exchange model
AMAN	Arrivals manager
AMHS	ATS message handling system
APV	Approach procedures with vertical guidance
ASBU	Aviation system block upgrades
ATM	Air traffic management
ATN	Aeronautical telecommunication network
ATS	Air traffic services
ATZ	Aerodrome traffic zone
Baro VNAV	Barometric vertical navigation
CAM	Collaborative arrivals manager
CAR	Civil aviation rule
CCO	Continuous climb operations
CDM	Collaborative decision making
CDO	Continuous descent operations
CPDLC	Controller pilot data link communications
CTA	Control area
DMAN	Departures manager
DME	Distance measuring equipment
DST	Decision support tools
FANS	Future air navigation system
FIS-B	Flight Information service - broadcast
FL	Flight level
FMC WPR	Flight management computer waypoint position reporting
FMS	Flight management system
GA	General aviation
GLS	Ground-based augmentation system
GNSS	Global navigation satellite system
GPS	Global positioning system
HF	High frequency
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
ILS	Instrument landing system
LDACS	L-Band digital aeronautical communication system
LNAV	Lateral navigation
MLAT	Multilateration
MSSR	Monopulse secondary surveillance radar
NOTAM	Notice to airmen
OCA	Oceanic control area
PBN	Performance-based navigation
RAIM	Receiver autonomous integrity monitoring
RNAV	Area navigation
RNP	Required navigation performance
RPA	Remotely piloted aircraft
SATCOM	Satellite communication
SBAS	Satellite-based augmentation system
SESAR	Single European Sky ATM Research
SID	Standard instrument departure
SNET	Ground-based safety net
SSR	Secondary surveillance radar
STAR	Standard instrument arrival
SURF	Safety and efficiency of surface operations
SWIM	System-wide information management
TIS-B	Traffic information service - broadcast
TMA	Terminal control area
UIR	Upper flight information region
VFR	Visual flight rules
VHF	Very high frequency
VNAV	Vertical navigation
VOIP	Voice over internet protocol
VOR	VHF omnidirectional radio range

Summary

Introduction

In recent years there have been significant technological advances in airspace management and air navigation services.

Satellite navigation now allows aircraft positions to be pinpointed to within a few metres, radar networks can be replaced by aircraft based surveillance systems, digital and satellite communication is developing, information is being digitised and integrated and air traffic control systems now allow more predictive aircraft management.

This modernisation of the airspace and air navigation system will improve the efficiency of air traffic movements, allow more accurate navigation, reduce reliance on ground-based systems, improve communications and increase availability of information for more effective decision-making. These changes will result in reduced operating costs and improved aviation safety.

There is a worldwide drive, led by the International Civil Aviation Organization (ICAO) to update the aviation system with these new technologies, and move towards an integrated and interoperable global air navigation system. ICAO has produced a Global Air Navigation Plan (GANP) to guide states in their transition to the new technologies. Many individual countries are moving ahead with their own plans, including the United States' Next-Gen programme and the Single European Sky ATM Research (SESAR) multinational project for European airspace.

The National Airspace and Air Navigation Plan

In line with international efforts, this National Airspace and Air Navigation Plan has been prepared to provide clear direction on the safe, cohesive, efficient and collaborative management of New Zealand's airspace and air navigation system over the next decade. It sets out the practical steps that need to be taken by all participants in New Zealand's aviation system to transition to the new technologies, and to effectively manage airspace as demand increases and technology advances. It has been developed as a key document under The National Airspace Policy of New Zealand (2012), and the National Infrastructure Plan (2011). It is also referenced as a key initiative in the Intelligent Transport Systems Action Plan, which outlines a proposed work programme on Intelligent Transport Systems for the next four years. It will be regularly reviewed.

The Plan is a guidance document. Future policy and regulatory development flowing from the Plan will go through full analytical and consultation processes. However, the level of detail contained within the plan is intended to provide the industry with a clear indication of the pathway that will be followed to modernise the aviation system and a strong indication of investments that may be required. It also signals when key policy and regulatory decisions will be made.

Key proposals

The Plan comprises eight chapters, covering Air Navigation, Surveillance, Communications, Aeronautical Information, Air Traffic Management, Airspace Design, Aerodromes and Meteorological Services. Proposed actions contained in the Plan are spread across 2014–15, 2016–18 and 2019–23. The key proposals contained in each area are summarised below.

Air navigation–ground-based to performance-based navigation (PBN)

Traditionally air navigation has relied on ground-based navigation aids to assist aircraft to fly safely during instrument (IFR) flights. The major change in air navigation over the next 10 years is a progressive transition worldwide to performance-based navigation (PBN) routes and departure and arrival procedures. PBN involves area navigation procedures that are more accurate and allow for shorter, more direct routes. They are often based on global navigation satellite systems (GNSS).

To make a safe transition to the new PBN environment, operators will need to ensure that their equipment, procedures and training meet acceptable standards. These will be further developed in rules and Advisory Circular AC91-21.

The Plan signals that a policy on whether New Zealand can introduce sole-means GNSS navigation will be completed by the end of 2015. The viability of Satellite-Based Augmentation Systems (SBAS) for New Zealand will be investigated.

Air navigation key proposals

- Progressively greater reliance on PBN aiming for a full PBN environment.
- A ground navigation aid contingency strategy to ensure adequate ground-based navigation aids remain.
- Equipment, operator and training requirements for operators wishing to use PBN detailed in Advisory Circulars e.g. AC 91-21.
- Supporting regulatory changes.
- Guidance, education and training standards developed for both operators and air traffic controllers to make the transition to PBN.
- Further investigation into options for sole means use of GNSS and SBAS for New Zealand.

Surveillance: reducing our reliance on radar

By 2021 New Zealand's primary and secondary radar network will reach the end of its life. The Plan signals the intention to replace it with Automatic Dependent Surveillance-Broadcast (ADS-B) technology as the primary method of air traffic control surveillance.

It is proposed that ADS-B systems, including Mode S 1090 extended squitter transponders, will need to be installed in aircraft that fly in controlled airspace – by 2018 for aircraft flying above 24,500 feet (FL 245), and by 2021 for all aircraft flying in controlled airspace. This will provide controllers with precise information about the position, identity and trajectory of aircraft, improving the safety of the system. It follows moves around the world to upgrade to this technology e.g. Australia and European Union by 2017 and United States by 2020.

Complete removal of the existing ground-based radar network is not envisaged, as this would result in too much reliance on the satellite system – especially with PBN also becoming heavily reliant on GNSS. A strategy for appropriate surveillance back-up will be developed to ensure that in case of GNSS failure, airborne aircraft can be recovered safely.

Careful consideration will need to be given to ensuring a smooth transition to the ADS-B environment, particularly for smaller operators where cost and practicality may create barriers. There will be opportunities over the next year to contribute to rule development setting the standards and requirements for ADS-B.

Surveillance key proposals

- Develop a strategy for decommissioning the radar network by 2021, ensuring that an adequate back-up surveillance network remains in place.
- Require ADS-B equipment to be installed on aircraft in a staged way:
  - From 2018: ADS-B carriage mandatory above FL 245
  - From 2021: ADS-B carriage mandatory in all controlled airspace.
- Develop and implement policy to ensure smooth transition to ADS-B for smaller commercial and private operators and monitor future changes in the technology.
- Implement an education programme for operators, pilots and air traffic controllers on ADS-B installation and operational requirements.
- Regulatory changes to allow implementation of ADS-B mandatory airspace and to set ADS-B avionics equipment standards.

Communications: incremental improvements

Aviation communications have been dominated by radio since the middle of last century. Some countries are considering Introduction of domestic data-link (digital messaging). However New Zealand's radio coverage and traffic volumes will not justify moves in this direction for some time. On-going maintenance of the very high frequency (VHF) radio network is therefore a key element of this Plan.

A number of complementary communications technologies will be explored further over the coming years. Data-link technology will be extended to some ground-ground communications and the technology as a whole will be reviewed in the future. SATVOICE (satellite voice communication) technology is already installed in many aircraft, and the Plan anticipates this technology being accepted as a primary means of voice communication in oceanic airspace. Voice over Internet Protocol (VoIP) will also be introduced to enable linking to remote sites and for ground communication. Internet Protocol is being developed for aircraft applications but is not anticipated to be viable until after 2016.

Exchange of messages and digital data between aviation users will be made more efficient through the transition to the Air Traffic Service Message Handling System (AMHS) and ultimately to the Aeronautical Telecommunication Network (ATN).

A key challenge in the future is communications for Remotely Piloted Aircraft Systems (RPAS). The longer term Remotely Piloted Aircraft policy project will need to include communications requirements to enable these aircraft to integrate into the system.

Communications key proposals

- VHF voice continues as the primary communication medium in the domestic environment.
- Accept SATVOICE as a primary communication medium in remote oceanic areas.
- Introduce new protocols for ground communications –ATN and VoIP.
- International pre-departure clearances via data-link from 2014.
- Longer term: Review demand for data-link in the domestic environment.
- Implement communications policy for Remotely Piloted Aircraft Systems (RPAS).

Aeronautical information management: digital and integrated

Aeronautical Information Services are still largely based on a suite of paper-based publications and charts with some online accessibility of information.

Over the next 10 years, the aviation system will become more responsive to demand, with the development of airborne navigation technology, surveillance systems and direct ground-air data-links.

To accommodate this, paper-based systems will need to progress to digital data-driven systems that allow continuous, up-to-date and real-time transfer of the full range of aeronautical information to all participants in the aviation system

New Zealand is well advanced in moving towards digitisation and integration of its aeronautical information products. More work is yet to be done in the areas of electronic charts, interoperability with meteorological products and the proliferation of devices which can now be used to access data. Care will need to be taken to ensure that human factors associated with data accessibility do not introduce new risks into the system.

Aeronautical information management: key proposals

- Complete digitisation of information, including completion of the aeronautical information conceptual model, aerodrome and obstacle mapping and electronic aeronautical charts.
- Ensure information management is integrated, including interoperability with meteorological products.
- Aim for new digital aeronautical data to be accessible in real time to all participants in the system – on the ground and in the air.
- Manage human factors associated with accessibility of data – including the use of new applications and devices.

Air traffic management: from controlling to enabling

Central to all the new technologies explored in this Plan is the presence of air traffic control – the current single coordination point for all air and ground operations.

The modern vision for the Air Traffic Management (ATM) system is based on the provision of services with a view to becoming air traffic enabling, rather than air traffic controlling.

New Zealand's small aviation system means that our ATM system is already reasonably well integrated. However on-going improvements to modern air traffic management tools, combined with the new surveillance, information and navigation technologies, will ensure more efficient flow management and conflict detection – reducing operator costs and improving safety.

Changes in the system lead to the need to ensure that contingency planning is up to date and all participants in the system are trained and aware of the new environment.

Air traffic management: key proposals

- Further develop and implement tools to move from the concept of tactical control to strategic control and enabling service provision for all ground and airborne elements of Air Traffic Management, including:
  - Synchronised network management
  - Trajectory-based management
  - Conformance monitoring
  - Conflict detection using trajectory prediction and conformance monitoring technology.
- Ensure adequate contingency planning to enable management during failures in the Air Traffic Management system.
- Educate, train and encourage all users (controllers and operators) to operate safely within the changing environment.
- Develop a performance framework to provide a measure of performance.

Airspace design: review and refine

The changes outlined in other parts of this Plan signal the need for New Zealand's airspace design and designations to be reviewed to accommodate increasing traffic, new types of aircraft and more direct and efficient flight paths.

For example, new performance-based navigation routes may change flight paths and is likely to reduce the volume of controlled airspace. New Zealand is also likely to see an expansion in remotely piloted aircraft activity and the space industry, including more rocket launch sites.

To accommodate these changes, airspace reviews will become more demand-driven, so clear triggers and methodologies will need to be developed in a consultative and inclusive way so that user needs are accommodated. Collaborative airspace forums will assist with this process.

As with any change, adjustments to airspace design introduce safety risk: training and information will need to be provided.

In the longer term, with the introduction of ADS-B providing more comprehensive surveillance coverage, the Plan signals a further review of transponder requirements in uncontrolled airspace, as well as a review of the regulatory requirements around airspace use during aircraft and civil emergencies.

Airspace design: key proposals

- Review existing designations to determine what changes or additions may be necessary.
- Airspace reviews to become more demand-driven and consultative. Develop triggers and methodology for airspace reviews to take into account significant changes in activity. Encourage collaborative airspace forums.
- Disseminate information and training to operators about changed routes and airspace structures.
- Reassess provisions relating to transponder requirements, including an assessment of whether uncontrolled airspace should be transponder mandatory.
- Consider what variations to airspace rules and procedures could be applicable to cover aircraft emergencies and civil emergencies.

Aerodromes: increasing capacity

Aerodrome infrastructure can be a limiting factor when attempting to improve traffic flows and improve system capacity.

This increasing pressure on aerodrome infrastructure means that airport management should be driven by a collaborative process of master planning, linking in with both airspace management requirements and land management planning to ensure a seamless service for passengers and operators.

Key challenges facing aerodrome management in the future include the need to ensure that there is sufficient movement area capacity at New Zealand's aerodromes, given the potential increased capacity in the air flowing from the changes in the Airspace and Air Navigation system. Communication between aerodrome operators and the air navigation service provider also needs to be coordinated, particularly to enable efficient management during localised weather and civil emergency events.

Linkage with land use planning remains an important part of any future aerodrome management. Appropriate resource planning processes are important to ensure that the needs of aviation stakeholders and the public are effectively addressed.

Aerodromes: key proposals

- Master plans for aerodromes should have regard to this Plan.
- Terminal and aerodrome design/geometry reviewed.
- Review implications for New Zealand's network of aerodromes flowing from changes in the airspace and air navigation system and develop policy and guidance to address implications if required.
- Establish formalised airport collaborative decision-making forums.
- Review critical infrastructure and systems to identify potential areas where further contingency measures are required.

Meteorological services: integrating weather data

Full integration of meteorological information into air traffic management and performance-based navigation applications will be an essential enabler for a future interoperable, seamless air traffic management system.

Core to this is the implementation of a Weather Information Exchange Model (WXXM) that will provide a common format for weather data and enable integration with aeronautical information systems.

Integration of weather data with other systems will enable real-time weather information to be provided directly to users, including into the cockpit. How pilots will access this data will also be addressed.

Meteorological services: key proposals

- Implement WXXM format for weather data.
- Aim to integrate weather data with aeronautical information systems.
- Aim for real-time weather information to air traffic controllers and into cockpit.
- Develop a sector-wide policy on the provision of, and access to, aeronautical meteorological information.

Context
A changing aviation system

Growth in aviation has been exponential since the 1970s, with increased social mobility and burgeoning international trade and tourism. Pressure is building to provide greater capacity and efficiency within the aviation system to serve this growth.

Technological shifts

A significant shift in aviation technology is also underway. Developments in many fields are opening the door to new opportunities for efficiency and safety improvement:

- Global navigation satellite systems can now pinpoint aircraft to within a few metres.
- Air traffic service surveillance is moving from ground-based radar to aircraft-based systems.
- Digital messaging (datalink) and satellite communications are supplementing traditional radio transmissions in communications.
- Information technologies are allowing us to integrate all aviation data to provide more complete information to pilots.
- More powerful computers are enabling the Introduction of complex predictive trajectory management.
- Remotely piloted aircraft systems are enabling the public to participate directly in the aviation system.

Ongoing modernisation of the aviation system will assist in the safe and efficient movement of air traffic, more accurate navigation, reduced reliance on ground-based systems and increased availability of information for more effective decision-making.

These new systems also allow for shorter, more direct routes, as well as more efficient departure and arrival flight paths. This reduces fuel burn, aircraft emissions, and facilitates the movement of air traffic.

However, unmanaged technological changes can also lead to increased safety risks when they outpace the regulatory and infrastructure developments needed to support it.

International harmonisation

There is a strong international drive for an integrated and interoperable global air navigation system, led by the International Civil Aviation Organisation (ICAO) with state and industry support. Alignment to the extent possible with international requirements is important to ensure that New Zealand maintains compatibility and interoperability with the international civil aviation system.

ICAO's 4th Global Air Navigation Plan (ICAO Doc 9750), outlines the expected availability of new technologies as Aviation System Block Upgrade (ASBU) modules with four five-year time increments starting in 2013 (Block 0) and continuing through 2028 and beyond (Block 3).

The ICAO Plan is not mandatory but provides a planning tool for states in supporting a harmonised global air navigation system. Where states determine a need for the modernisation of their airspace and air navigation systems, it is recommended they follow the applicable modules set out in the ICAO Plan.

The Asia-Pacific region has also developed a regional plan to guide states in development and ensure regional harmonisation. The ICAO Asia-Pacific Seamless Air Traffic Management Plan has been taken into account to ensure this Plan aligns with identified regional outcomes.

Many states are in the process of developing their own plans to take advantage of the changing technologies to improve traffic flow, efficiency, safety and environmental performance.

These plans include the NextGen programme in the United States and the Single European Sky Air Traffic Management Research (SESAR) multinational project for European airspace. Many countries and regions, including Australia, Canada and the United Kingdom are also well on their way to implementing their own plans.

The National Airspace Policy

New Zealand has made good progress in the development of policies to take advantage of aviation growth, technological changes and the international drive for harmonisation. In April 2012, the Government issued The National Airspace Policy Statement (Box 1).

The Policy provides overarching principles and desirable attributes that will guide regulators and industry in the development and modernization of the airspace and air navigation system over the next decade.

The National Airspace Policy aligns with the National Infrastructure Plan 2011. This Plan is designed to reduce uncertainty for businesses by outlining the Government's intentions for infrastructure development over a 20 year timeframe. Key principles identified in the Plan include:

- **Investment analysis:** Investment is well analysed and takes sufficient account of changes in demand.
- **Resilience:** National infrastructure networks are able to deal with significant disruption and changing circumstances.
- **Funding mechanisms:** Use of a broad range of tools.
- Accountability and Performance: It is clear who is making decisions, and on what basis, and what outcomes are being sought.
- **Regulation:** enables investment in infrastructure that is consistent with other principles, and reduces lead times and uncertainty.
- **Coordination:** Infrastructure decisions are well coordinated across different providers.

Box 1: The National Airspace Policy

New Zealand's National Airspace Policy seeks "a safe and capable airspace and air navigation system both within New Zealand and the international airspace it manages, that measures up to international safety standards and best practices, and contributes to economic growth through efficiency gains".

It sets out four principles for the future administration of New Zealand's airspace by the Civil Aviation Authority:

- **Safety** – that New Zealand's airspace will be managed holistically with safety as the principal objective.
- **Compatibility** – that New Zealand's airspace classification and air traffic services shall be compatible with international standards or best practice; and that New Zealand will manage international airspace assigned to it by the International Civil Aviation Organization consistent with international standards and best practice.
- **Protection of national interests** – the Civil Aviation Authority will continue to be able to designate areas of restricted airspace for military purposes, national emergencies, search and rescue operations, and in any other situation where it is deemed necessary in the interests of safety. Under normal circumstances, the New Zealand Defence Force is expected to have regard to the Civil Aviation Authority's designation of airspace in its operations, but under exceptional circumstances it will be able to operate freely and without restriction in any New Zealand airspace.
- **Accessibility** – except where restrictions on airspace access are necessary for safety, operational, or other reasons, all aircraft will be able to access such classes of airspace that the aircraft and crew are able to operate safely within.

It also identifies two principles relating to the future provision of air traffic management and air navigation services (currently the Airways Corporation of New Zealand (Airways) is the sole provider, but aerodrome air traffic services are contestable):

- **Funding** – the cost of providing services will continue to be recovered on a commercial basis with regard to legislation and, where appropriate, charging guidelines issued by the International Civil Aviation Organization.
- **Resilience** – the supporting systems and infrastructure will ensure that any disruption to the network as a result of natural disasters or interference is mitigated to the extent possible.

The policy also sets out a number of other desired attributes of New Zealand's future airspace and air navigation system, which will be pursued as much as possible without compromising safety:

Efficient – the air navigation system and the design and classification of airspace will facilitate the efficient operation of aircraft within New Zealand airspace.

- **Environmentally responsible** – the future airspace and air navigation system will be respectful of the impacts of aviation on the environment, and any development that can reduce the overall environmental impact of aviation will be pursued, as long as it can be achieved safely and at reasonable cost.
- **Integrated** –the aviation sector and local authorities will proactively address their respective interests in any future planning to facilitate the adoption of more efficient aircraft arrival and departure paths in a timely way and to avoid or mitigate incompatible land uses or activities and potential impacts or hazards that will impact, or have the potential to impact, on the safe and efficient operation of aircraft.
- **Interoperable** – The National Airspace and Air Navigation Plan will be compatible with other global and regional plans, including the International Civil Aviation Organization's Global Air Navigation Plan, as much as practicable, while taking into account any unique aspects of airspace and air traffic management in New Zealand.

The National Airspace and Air Navigation Plan

This National Airspace and Air Navigation Plan is guided by the principles and desirable attributes set out in the National Airspace Policy as well as the national direction set in the National Infrastructure Plan and international direction set by ICAO. It is one of the five key Government actions for aviation set out in *Connecting New Zealand – A Summary of the Government's Policy Direction for Transport* (2011). It is also referenced as a key initiative in the Intelligent Transport Systems Action Plan.

The Plan is a non-binding guidance document. Future policy and regulatory development flowing from the objectives, principles and actions in the plan will go through full analytical and consultation processes. However, the level of detail contained within the Plan is intended to provide industry with a clear indication of the pathway that will be followed to modernise the aviation system and a strong indication of the future investments that may be required. It also signals when key policy and regulatory decisions will be made.

Plan objectives

The Plan's key objective is: To provide clear direction on the safe, cohesive, efficient and collaborative management of New Zealand's airspace and air navigation system over the next decade.

To achieve this it will:

- Phase in new systems and technologies in a systematic and orderly manner.
- Identify and mitigate the risks associated with technology and process change.
- Ensure that there are adequate contingencies in the event of system failure.
- Address human factors issues associated with changing systems.
- Align as far as possible with international standards and practices, particularly ICAO and Asia-Pacific regional requirements.
- Provide directions for system-wide coordination of all aspects of our airspace management system.
- Encourage linkages across regulatory regimes to ensure integration with respect to environmental management including land use.
- Be technology-enabling, not technology-driven.
- Optimise the efficiency of passenger transport.
- Ensure reasonable ongoing access for the GA community.
- Ensure that ongoing service will be provided to operators with compliant equipage.
- Be practical and achievable.
- Encourage collaborative mechanisms to address different needs of aviation system users and the public in airspace management.
- Encourage early uptake of the technology.

The actions identified in the Plan have been developed taking the following into account:

- Aircraft equipment requirements.
- Infrastructure development.
- Contingency and emergency systems.
- Procedures and management tools.
- Education and training requirements.
- Information requirements.
- Associated regulatory changes.

Ongoing review

This Plan will be a living document, with regular reviews to coincide with the key stages set out on the Plan – 2018 and 2023. This does not preclude reviews of the Plan in the intervening years, should new technological or international developments warrant the need.

Performance measures will be based on an assessment of whether the Plan's objectives have been achieved, and whether the actions contained within the Plan have been delivered.

New Southern Sky at a glance

	Stage 1 by end of 2015	Stage 2 by end of 2018	Stage 3 by end of 2023
Navigation *Ground-based to performance-based navigation* *Pg 17*	Continued use of legacy navigation applications while PBN capability is progressively implemented in aircraft fleets and the supporting infrastructure. The ground infrastructure associated with legacy navigation systems will be reviewed and progressively adapted.	Move to a more exclusive PBN environment that places greater reliance on the level of PBN capability in the national fleet and infrastructure. The ATM system will be managing a more homogeneous navigation capability.	A mature PBN environment with a comprehensive fleet and infrastructure capability. Air traffic management tools complement airborne systems and enable the management of those aircraft that may experience temporary loss of PBN capability. Contingency ground infrastructure that enables all aircraft to safely return to the ground.
Surveillance *Reducing our reliance on radar* *Pg 25*	Planning for progressive implementation of ADS-B, including rule development and training and education programme development.	ADS-B exclusive airspace above FL 245 with supporting network of ADS-B receivers.	ADS-B exclusive in all controlled airspace. Some provision for back-up ground surveillance network and special areas for non-ADS-B equipped aircraft.
Communications *Incremental Improvements* *Pg 31*	Ongoing maintenance of the VHF network. Complete transition from AFTN to AMHS. Develop policy for Remotely Piloted Aircraft.	International pre-departure clearances via data-link. Review demand for additional use of data-link technology. VoIP for ground and remote communications. Implement Remotely Piloted Aircraft Policy.	VHF communication remains the primary means of domestic communication. Approve SATVOICE as a primary means of communication in oceanic controlled airspace. Implement results of review on Data-link technology. Transition to ATN protocol.
Aeronautical Information Management *Digital and integrated* *Pg 37*	Going digital: transition from AIS to AIM in accordance with ICAO roadmap.	Information management – system integration through common data standards and communications.	Real-time availability of aeronautical information and data into aircraft.

	Stage 1 by end of 2015	Stage 2 by end of 2018	Stage 3 by end of 2023
Air Traffic Management *From controlling to enabling* *Pg 43*	Infrastructure, procedure and tool development towards trajectory-based management including education programmes.	Implementation of trajectory-based management tools, training programmes.	Trajectory-based management in place, supported by integrated information and collaborative processes.
Airspace Design *Review and refine* *Pg 49*	Review existing designations and develop methodology and triggers for future reviews.	Full review of New Zealand airspace to be completed by this time.	Revised airspace in place, review options for transponder mandatory in uncontrolled airspace and for reduced need for control areas with greater use of aircraft self-separation.
Aerodromes *Increasing capacity* *Pg 53*	Establish collaborative decision-making forums and ensure effective contingency plans are in place.	Ensure that New Zealand's network of airports can support the changes occurring in the airspace and air navigation system.	Aerodrome master plans have regard to objectives and actions set out in the Plan.
Meteorological Services *Integrating weather information* *Pg 59*	Develop WXXM format for weather reporting.	Integration of weather data with aeronautical information.	Real-time availability of weather data into aircraft.

Air Navigation
Ground-based to performance-based navigation

Introduction

Air navigation is the process of planning, directing, and monitoring the movement of an aircraft from one place to another.

In the early days of flight, aircraft were navigated visually by dead reckoning–identifying geographical points with the aid of maps and compasses. Reasonable weather conditions were needed so that pilots could keep the ground in sight.

After the Second World War, new technologies were introduced to enable pilots to find their way without the need for visual reference. New types of ground-based navigation aids (such as NDB, VOR/DME and ILS – see Box 2) were installed that allowed aircraft to navigate along fixed routes and to conduct instrument approach and departures from aerodromes.

The early 1980s heralded the development of Global Navigation Satellite Systems (GNSS) – a network of orbiting satellites, which together provide total global coverage. The most well-known GNSS system is the United States' Global Positioning System (GPS). The Russian system is GLONASS. China and the EU are also developing systems (BeiDou and Galileo respectively), which are expected to be operational by 2020.

GNSS systems are unconstrained by the location, accuracy and terrain limitations associated with ground navigation aids and allow more precise aviation navigation. Aircraft equipped with GNSS receivers can identify their positions accurately at all points along their route – introducing a new level of flexibility and accuracy into aircraft navigation.

However, this system relies on the performance of the GNSS receivers on board the aircraft. There is a wide range of products available on the market today, but many of these do not have the accuracy, integrity, continuity and functionality required to ensure the safety of the flight. The reliability of the satellite networks is also critical to the success of the new system.

Performance-based navigation

Performance specifications are therefore needed to ensure that the receiving equipment on board the aircraft meets the appropriate standards. This has given rise to the term performance-based navigation (PBN).

Performance-based navigation involves use of area navigation procedures, which are more accurate and allow for shorter, more direct flights.

In the future, performance-based navigation based on GNSS will become the primary method for flights operating under instrument flight rules (IFR).

There are two types of navigation performance specifications in performance-based Navigation:

- **RNAV** (aRea NAVigation) A method of navigation that permits aircraft operation on any desired flight path within the coverage of ground- or space-based navigation aids or within the limits of the capability of self-contained aids, or a combination of these[1].

1 Area navigation includes performance-based navigation as well as other RNAV operations that do not meet the definition of performance-based navigation.

- **RNP** (Required Navigation Performance) allows an aircraft to fly a specific path between two three-dimensionally defined points in space. The key difference between RNAV and RNP is that RNP requires on-board performance monitoring and alerting so that the pilot is notified early of any reduced satellite coverage, and is therefore a more robust system. For example, GNSS with Receiver Autonomous Integrity Monitoring (RAIM) meets the required standards.

RNAV instrument approach procedures can be augmented with lateral and vertical guidance – called Approach Procedures with Vertical guidance (APV). These do not meet the requirements established for precision approach and landing operations.

Box 2: Navigation definitions

VOR: VHF Omnidirectional Radio Range – A ground-based radio transmitter that sends out directional radio signals to guide aircraft.

NDB: A ground-based radio transmitter at a known location. Its signal does not include inherent directional information, in contrast to VOR.

DME: Distance measuring equipment on board aircraft that allows the pilot to measure the distance to a ground-based navigation station.

DME/DME: Aircraft can take position fixes from two ground stations to determine position. DME/DME/IRU is similar but the aircraft uses an on-board inertial reference unit to monitor progress when DME coverage is interrupted.

ILS: Instrument landing system – an antenna array based at the airport that guides aircraft in to land.

APV: Approach with vertical guidance – uses either SBAS (Satellite Based Augmentation Systems) or Baro-VNAV systems to enable approaches with greater vertical precision. The former requires a network of ground-based reference stations and a geostationary satellite to transmit correction data to the aircraft GNSS, while the latter requires special equipment on board aircraft to calculate the correction factors.

- Ensure that there are adequate contingencies in the event of system failure.
- Address human factors issues associated with changing systems.
- Align as far as possible with international standards and practices, particularly ICAO and Asia-Pacific regional requirements.
- Provide directions for system-wide coordination of all aspects of our airspace management system.

International developments

The move to performance-based navigation was signalled in 2007 with a resolution of the Assembly of the International Civil Aviation Organization (ICAO) calling on member states to complete an implementation plan for performance-based navigation by the end of 2009. In summary, state plans should achieve:

- Implementation of RNAV and RNP operations (where required) for en-route and terminal areas, according to established timelines and intermediate milestones.
- Implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or augmented GNSS - SBAS), including LNAV (lateral guidance only) minima, for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016, with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014.
- Implementation of straight-in LNAV (lateral guidance only) procedures at aerodromes where VNAV (vertical guidance) is technically not possible, or where there is no local altimeter setting available and where there are no aircraft suitably equipped for APV operations, with a maximum certificated take-off mass of 5,700 kg or more.

It also urged that states include provisions in their PBN implementation plan for creation of approach procedures with vertical guidance (APV) to all runway ends serving aircraft with a maximum certificated take-off mass of 5,700 kg or more, according to established timelines and intermediate milestones.

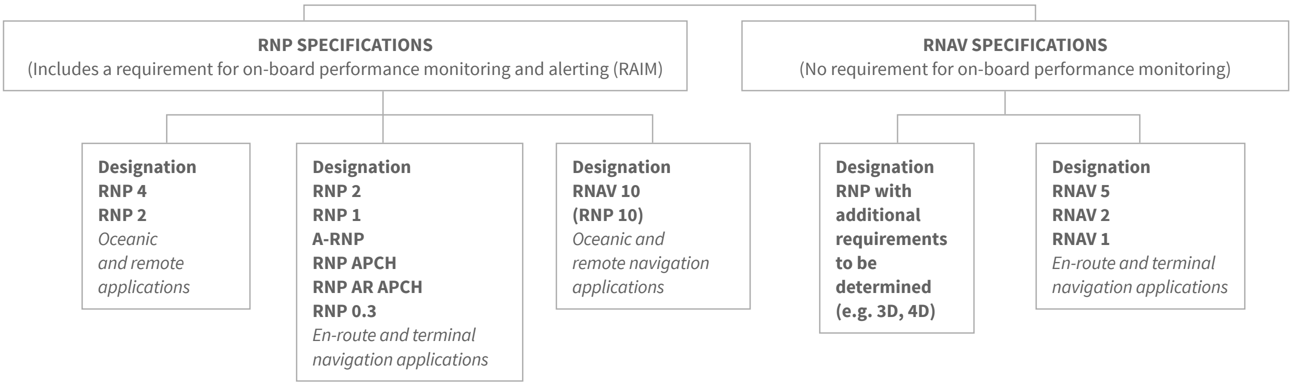
ICAO developed a set of specifications to guide States in the development of their own plans (see Figure 1), and provided guidance material on implementation in the PBN Manual (Doc 9613).

A significant amount of international effort is going into improving the accuracy and reliability of satellite navigation systems. ICAO notes that the United States, GPS system will provide signals on two frequencies by 2018. New satellite constellations from Europe (Galileo) and China (BeiDou) are coming online in the next five years. The availability of multiple frequencies could reduce ionospheric errors. This will allow a further increase in accuracy from 2018 and beyond.

Performance-based navigation implementation is well advanced in many countries; for example:

- Australia has over 500 PBN approach procedures with plans to add LNAV/VNAV. Australia has also completed a Ground Landing System Category 1 trial at Sydney.
- The United States has over 5000 PBN approaches, with almost 2500 having LNAV/VNAV and LPV minima (based on its version of SBAS, the Wide Area Augmentation System WAAS). Of the procedures with LPV minima, almost 500 allow the aircraft to approach with 200 ft cloud base.

Figure 1: ICAO specifications for performance-based navigation



The numerical designators define the level of accuracy required of the navigation system, for example RNP 2 should accurately pinpoint the aircraft to within two nautical miles, 95 percent of the time.
The RNP APCH (Required Navigation Performance APproaCH) specifications require a standard navigation accuracy of 1.0 NM in the initial, intermediate and missed segments and 0.3 NM in the final segment.
The RNAV 10 specification was previously called RNP 10 and is still called RNP 10 in some documents

Table 1: ICAO block upgrades related to navigation

	Block 0	Block 1	Block 2	Block 3
Improved Flexibility and Efficiency in Descent Profiles - Continuous Descent Operations (CDO)	Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Continuous Descent Operations (CDOs).	Deployment of performance-based airspace and arrival procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Optimised Profile Descents (OPDs).	Deployment of performance-based airspace and arrival procedures that optimise the aircraft profile taking account of airspace and traffic complexity including Optimised Profile Descents (OPDs) supported by trajectory-based operations and self-separation.	
Improved Flexibility and Efficiency in Departure Profiles - Continuous Climb Operations (CCO)	Deployment of departure procedures that allow the aircraft to fly their optimum aircraft profile taking account of airspace and traffic complexity with Continuous Climb Operations (CCOs).			
Development of GNSS-based approaches (APTA)	Optimisation of approach procedures including vertical guidance – as the first step towards universal implementation of GNSS approaches – includes GNSS, Baro vertical navigation (Baro VNAV), Satellite-Based Augmentation system (SBAS) and Ground-based Augmentation System (GLS).	Taking advantage of the lowest possible minima through the extension of GNSS approaches from Cat I to Cat II and III capability at a limited number of airports. Harness integration of PBN Standard Arrival Routes (STARS) directly to all approaches with vertical guidance allows for both curved approaches and segmented approaches in an integrated system.		

Current status of aviation navigation in New Zealand

Navigation in New Zealand has traditionally relied upon a network of ground-based navigation aids[2] that pilots use to navigate along fixed routes (route navigation) and to make instrument approaches and departures at aerodromes.

In 1997, New Zealand was one of the first countries in the world to implement rules to allow instrument flight procedure operations using GPS. However, these rules have not been updated to reflect the modern use of GNSS.

PBN implementation progress

In 2009, ICAO resolved that all states should develop a Performance Based Navigation Implementation Plan. In response New Zealand published its PBN Implementation Plan. It was one of the first to be produced and was internationally recognised as a model for others.

The agreed concepts for New Zealand are to be implemented through a three-phase process with target implementation dates of 2012, 2017 and 2020. Through this process, all Air Traffic Service routes (including Standard Instrument Departures–SIDs and Standard Arrival Routes–STARs) will be enabled by RNAV (or RNP, where required). All runway ends with instrument approach procedures will be enabled by RNP (with APV where possible based on Baro-VNAV).

The Plan adopted the following standards for New Zealand domestic PBN:

- RNAV 2 for en-route operations.
- RNAV 1 for all terminal routes with surveillance services and Basic RNP 1 for routes without surveillance services.

For approach operations – RNP APCH. The legacy RNAV (GNSS) arrivals, RNAV (GNSS) SIDs, and RNAV (GNSS) approach procedures currently used in New Zealand are being replaced with the above specifications as they are reviewed.

As a result of this early planning, design and implementation of RNAV routes and procedures is well advanced. Existing ground-based navigation aids remain in operation and operators currently have a choice between the existing navigation systems and performance-based navigation procedures in many parts of the country. Certificated Part 173 Instrument Flight Procedure Design organisations have a significant workload in turning the design work into published documents.

The following procedures are already promulgated:

Routes

- RNP 10 (RNAV 10) and RNP 4 in Auckland Oceanic airspace.
- All domestic RNAV ATS routes were designated RNAV 2 on 15 November 2012.
- Arrival and departure procedures.
- RNAV(GNSS) approach procedures at most aerodromes to replace or complement existing ground-based instrument procedures.
- RNAV (GNSS) arrival and departure procedures (RNP 1 application) at selected regional aerodromes.
- Approach with vertical guidance based on Barometric Vertical Navigation (Baro-VNAV) criteria at all international airports.
- RNAV Standard Instrument Departure Routes (SIDs) and Standard Arrival Routes (STARs) being implemented at Auckland, Wellington, and Christchurch aerodromes.
- RNP AR APCH procedures at selected terrain-challenged locations e.g. Queenstown and Rotorua.

Regulatory requirements

The navigation equipment requirement and use standards are specified in Civil Aviation Rule 91.501(2) which states that *"a person shall not operate an aircraft unless the instruments and equipment installed in the aircraft comply with [a specified list] or an alternative specification and design standard approved by the Director".*

The acceptable standards for equipment use on PBN routes and approach procedures are currently provided in Advisory Circular AC 91-21 Rev 1 Performance Based Navigation (Operational Approvals). It sets out equipment standards, procedural and training requirements for operators wishing to use PBN routes.

Until rule changes can be implemented, the Director of Civil Aviation has issued a general exemption from some of the Part 19 Subpart D rules that limit the use of GNSS, provided it is in compliance with the requirements of Advisory Circular AC91-21 currently under review.

Equipment approvals: All navigation equipment installations to be used for performance-based navigation will require approvals (recorded on Form CAA 2129).

Operator approvals: Operational approval will also be required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

- Maintenance procedures (including maintenance of the navigation database).
- Pre-flight planning requirements.
- General operating procedures.
- Contingency procedures.
- Training requirements.

Pilot approvals: Pilots may conduct performance-based navigation operations only if they have an appropriate instrument rating for the navigation system and meet the currency requirement.

Infrastructure developments

Airways has a performance-based navigation implementation plan for all controlled aerodromes, which is being rolled out for completion in 2017; this plan covers instrument procedure design and associated ATC training.

Some large operators, including Air New Zealand, have also developed their own performance- based navigation implementation plans.

Challenges for New Zealand

A number of challenges will need to be addressed in the navigation area:

Safety management during transition to PBN environment

The key challenge during this transitional period is to ensure that all safety issues relating to implementation of the new procedures are effectively addressed – in particular that:

- Operators wishing to use the new routes have certainty about expectations and the equipment capabilities, operational procedures and training to manage the new routes.
- PBN is effectively implemented into the air traffic management system.
- Navigation databases are accurate, reliable, and from an approved provider.
- Weather information supports PBN use.

Reliability of the satellite system – contingency

While there are contingency systems in place during a mixed-mode navigation system, a more PBN-focused environment will mean that there are fewer alternatives available in the event of a GNSS outage. There is a great deal of work underway internationally to assess the reliability of the satellite system and there may be improvements in this area from about 2018 onwards.

A key challenge for New Zealand will be to ensure that there is an adequate ground-based navigation network to provide a safe alternate in the case of a failure of the satellite system.

GNSS system performance and prediction of continued availability of the service needs to be assured.

Upgrade costs and practicality

Aircraft operating in New Zealand airspace currently have a diverse range of navigational capabilities. This diversity, coupled with a wide mix of aviation activities, a high level of non-commercial operations and an older aircraft fleet, mean that not all participants will have the level of equipage to meet future requirements and that upgrading costs will vary greatly.

A balance will need to be struck between the needs of the operators who are driving towards an exclusive PBN environment (which will allow best cost savings) and the needs of some participants in the aviation system, in particular some in the general aviation community, for whom cost may outweigh benefits until equipment costs reduce.

In addition, there are some practical implications to take into account, New Zealand only has a small number of avionics engineers experienced in the new technology and is reliant on supply of equipment from overseas. Time will be needed to allow operators to arrange for upgrades and there may be impacts on the operation of both existing and new aircraft systems.

Changes in environmental impacts

The performance-based navigation routes are expected to have a positive effect on emissions, with less fuel burn and reduced carbon emissions.

Widespread change to air navigation routes, approaches and departures may result in changes to overall noise patterns resulting from more accurate tracks over particular areas. This is most likely to affect areas close to aerodromes with more accurate arrival and departure flight paths.

2. Non-Directional Beacons (NDB), Very High Frequency Omnidirectional Radio Range (VOR)/Distance Measuring Equipment (DME), and Instrument Landing Systems (ILS).
3. Distance-based separations for RNP10 aircraft and for RNP4 aircraft require surveillance via ADS-C and communications to RCP240 via CPDLC .

Outdated regulatory requirements

There are also issues relating to the existing rule set, which has not kept up with the new technologies. For example, a general exemption is currently in place to allow GNSS to be used as the primary means of navigation (Civil Aviation Rule Part 19 currently does not allow this).

Aspects of the Advisory Circular setting out the future regulatory requirements may need to be included in the rules.

Regulator resourcing

The introduction of processes to approve aircraft systems, operator procedures and implement training requirements will require significant resourcing from the Civil Aviation Authority (CAA). Time will be needed to allow for regulatory approvals, and resources will need to be set aside to implement a performance-based navigation capability register.

Plan for navigation

Stage 1 2014-2015 Mixed mode – continued use of legacy navigation applications while PBN capability is progressively implemented in aircraft fleets and the supporting infrastructure. The ground infrastructure associated with legacy navigation systems will be reviewed and progressively adapted.

Stage 2 2016-2018 Some exclusive PBN environments: move to a more exclusive PBN environment that places greater reliance on the level of PBN capability in the national fleet and infrastructure. The ATM system will be managing a more homogeneous navigation capability.

Stage 3 2019-2023 Full PBN environment, with some system redundancy. A mature set of air traffic management tools will complement the airborne systems and will also enable the effective management of those aircraft that may experience a temporary loss of PBN capability. All ATS routes (including Standard Instrument Departures and Standard Terminal Arrival Routes) will be enabled by RNAV (or RNP, where required). All runway ends with instrument approach procedures will be enabled by RNP (with APV where possible based on Baro-VNAV).

Objectives

- Implement PBN routes to enable progressively greater dependence on PBN:
  - Initially to support key routes for larger operators.
  - Ultimately by all IFR aircraft conducting instrument approaches and air traffic service routes in both oceanic and domestic airspace (both RNAV and RNP specifications).
  - Aiming for a sole-means GNSS navigation environment.
- Develop and implement a ground navigation aid strategy by end 2014. The strategy should be developed consultatively and:
  - Ensure that in case of a GNSS outage, all airborne aircraft can be safely recovered.
  - Ensure continuity of service can be maintained on the main trunk routes.
- Equipment, operator and training requirements for PBN to be implemented as detailed in Advisory Circular AC 91-21 (to be developed by end 2014).
- Guidance, education and training standards developed for both operators and air traffic controllers to make the transition to a PBN environment.
- Ensure that the policy and regulatory framework supports the changes.
- Complete further analysis on the following areas:
  - Complete technical and policy analysis on implications of sole means GNSS for New Zealand.
  - The need for Satellite Based Augmentation Systems (SBAS).
  - Requirement for GNSS Landing Systems (GLS).
  - Option to transition from single GNSS to multi-constellation GNSS.

Principles

- Encourage early uptake of the technology.
- Ensure that there is sufficient time allowed for aircraft to be equipped, and operators and pilots and air traffic controllers appropriately skilled in the new modes of navigation.
- Through all stages, a collaborative and participatory approach between instrument procedure design organisations, operators, aerodrome operators and affected communities will ensure smooth transition.
- Accommodate mixed-equipage operations until a full PBN environment is in place.
- Implementation of the navigation portion of the CNS/ATM system is capable of supporting the operational airspace concept.
- Equipment requirements minimise the number of equipment types required on board aircraft and on the ground.

Navigation actions

Key Objectives	Stage 1 2014-2015 *Mixed mode*	Stage 2 2016-2018 *Some exclusive PBN environments:*	Stage 3 2019-2023 *Full PBN environment, with some system redundancy.*
Implement PBN routes to enable progressively greater dependence on PBN – initially to support key routes for larger operators and ultimately aiming for a sole-means GNSS navigation environment.	RNAV 10 and RNP 4 in Oceanic airspace. RNAV 2 for routes. RNAV 1 for all terminal routes with surveillance services and basic RNP 1 for routes without surveillance services. At least one ground-based instrument approach procedure retained for each main runway end at controlled aerodromes.	RNP 2 in routes above FL 145. RNP APCH (RNAV GNSS) with APV where possible and RNP AR APCH as required. Includes helicopter routes. Review A-RNP specifications.	All routes (including SIDs and STARs) will be enabled by RNAV (or RNP, where required). All runway ends with instrument approach procedures will be enabled by RNP (with APV where possible based on Baro-VNAV).
Develop and implement a clear strategy to identify which ground navigation aids should remain in place as a contingency in case of emergencies and equipment failures.	Develop Navigation Aid Contingency Strategy using a consultative process by end 2014 • In case of a GNSS outage, all airborne aircraft can be safely recovered. • Continuity of service can be maintained on the main trunk routes. • Retain ILS at major international airports and their alternates.	Decommissioning of some terrestrial navigation systems in accordance with Navigation Aid Contingency Strategy.	Navigation Aid Contingency Network in place.
Equipment, operator and training requirements for PBN to be implemented as detailed in Advisory Circular AC 91-21 Rev A.	Operators wishing to use promulgated PBN Routes to comply with equipment, procedure and training specifications in Advisory Circular AC91-21.		All IFR operators to be approved for PBN navigation.
Guidance and education for operators to make the transition to a PBN environment.	Develop guidance and education programme for affected operators, pilots and air traffic controllers.	Implement guidance and education programme.	
Training standards revised for pilots flying PBN routes	IFR training standards updated and promulgated.		
Ensure that the policy and regulatory framework supports the changes.	Revoke Part 19 GPS rules and replace with new operational rules. Complete analysis on 'sole use' navigation for domestic IFR flight by end 2014.	Complete analysis on the costs and benefits of a Satellite Based Augmentation System.	

Surveillance

Reducing our reliance on radar

Introduction

The primary purpose of air traffic control worldwide is to prevent collisions between aircraft.

Early en-route controllers kept track of the position of aircraft with the help of maps and blackboards. They had no direct radio link with aircraft. Instead, they used telephones to stay in touch with airline dispatchers, airway radio operators, and airport traffic controllers.

The introduction of radar during the Second World War created a step change in aircraft tracking. By the 1960s, radar surveillance of civil aircraft gave air traffic controllers more accurate knowledge of aircraft position, which allowed closer aircraft spacing and greater efficiency.

There are two types of radar:

- **Primary surveillance radar (PSR)** transmits a series of pulses that are reflected by aircraft. The range and bearing of each aircraft detected is presented to the controller. Primary surveillance radar cannot identify aircraft, and is also prone to receiving false targets e.g. rain, birds, etc.
- **Secondary surveillance radar (SSR)** not only detects and measures the range and bearing of aircraft, but also requests additional information from the aircraft itself, such as its identity and altitude. Secondary surveillance radar relies on aircraft equipped with a transponder; the transponder replies to each interrogation signal by transmitting a response containing encoded data. Transponders are mandatory in controlled airspace in New Zealand.

Multilateration (MLAT) is a more recent ground-based surveillance technique. A number of ground stations in strategic locations interrogate and receive replies from aircraft SSR transponders. The time difference of arrival of a reply at four or more ground stations allows the system to calculate the position of the aircraft. Multilateration targets are updated typically once per second, compared with five-second intervals for radar targets.

Automatic dependent surveillance-broadcast (ADS-B) transponders broadcast an aircraft's position, altitude, velocity and other aircraft-derived data once or twice per second. This data is received by relatively simple ground stations and is fed to air traffic control displays, providing controllers with richer and more accurate information, which enables more efficient traffic flow and improves safety.

Aircraft equipped with **ADS-B IN** can also receive ADS-B transmissions from other aircraft. ADS-B IN is expected to eventually replace the existing aircraft collision avoidance systems. Trials using ADS-B IN for specific types of self-separation, such as in-trail climb, are being conducted. Self-separation is unlikely to be adopted in New Zealand domestic airspace for many years.

An ADS-B system can also be enhanced with graphical weather information overlay from Traffic Information Service-Broadcast (TIS-B) and Flight Information Service-Broadcast (FIS-B) applications. It also provides infrastructure for inexpensive flight tracking, planning, and dispatch.

An aircraft ADS-B system requires a 1090 MHz Extended Squitter (1090 ES) transponder with an input from a GNSS receiver, either directly or via the flight management system. This is the system adopted internationally.

An alternative system employing a Universal Access Transceiver (UAT) is used only in North America and only for aircraft operating below certain levels. While UAT uses simpler technology in the aircraft, it is not compatible with 1090 Extended Squitter. To employ both systems in New Zealand would require both 1090 Extended Squitter and UAT ground equipment at each site; the cost would be prohibitive.

International developments

ADS-B will become the main surveillance technology for controlling aircraft worldwide. ADS-B is compatible with other surveillance systems, such as multilateration.

ICAO advocates the transition to ADS-B where ATS surveillance is required. This is reflected in the ICAO Global Navigation Plan (see Table 2)

Table 2: ICAO block upgrades related to surveillance

	Block 0	Block 1	Block 2	Block 3
Ground surveillance (ASUR)	Ground surveillance supported by ADSB-Out and/or Wide Area Multilateration systems will improve safety and capacity through separation reductions.			
Improved access to optimum flight levels (OPFL)	Allow climb and descent procedures using ADS-B – prevents aircraft being trapped at a sub-optimal altitude and reduces fuel burn.			

Other countries have already made progress towards implementation of ADS-B.

United States: ADS-B is an integral component of the United States Next-Gen National Airspace Strategy for aviation infrastructure and operations. From January 2020, aircraft in controlled airspace where a Mode C transponder is now required will require an FAA-approved ADS-B system.

Australia: Deadlines for carriage of ADS-B transponders are:

- 12 December 2013: all aircraft operating at or above FL 290.
- 6 February 2014: all newly registered IFR aircraft and any newly registered recreational VFR aircraft operating in controlled airspace.
- 4 February 2016: all IFR aircraft operating in class A, B, C or E airspace around Perth.
- 2 February 2017: all IFR aircraft operating in class A, B, C or E airspace.
- 1 January 2020: all VFR aircraft operating in class A, B, C or E airspace.

EU: In the EU, airspace aircraft with a weight above 5,700 kilograms or a maximum cruise speed of over 250 knots will be required to carry ADS-B from 2017 (new aircraft from 2015).

Canada: Canada has implemented ADS-B technology in the Hudson Bay area, with estimated savings of $158 million in fuel per annum.

Status of New Zealand surveillance

In New Zealand, Airways provides radar coverage of most controlled en-route and terminal airspace using Monopulse Secondary Surveillance Radar (MSSR), with local areas of primary surveillance radar and multilateration.

- In the Auckland Oceanic Flight Information Region, surveillance is through Automatic Dependent Surveillance contract (ADS-C[4]), Controller Pilot Data Link Communications (CPDLC) position reports, Flight Management Computer Waypoint Position Reporting (FMC WPR)[5] via data-link, and voice position reporting via HF radio and, in special circumstances, via satellite (SATVOICE).
- Multilateration is used for surface movement surveillance at Auckland International Airport.
- Wide-area multilateration coverage of the Queenstown area is being extended to cover most of Otago and Southland.

Airways has signaled its intention to decommission the ageing radar network by 2021 and replace it with a network of ADS-B receivers and greater use of wide-area multilateration.

4. ADS-C transmits position and intent information in response to a 'contract' established by ATC.
5. Flight Management Computer Waypoint Reporting. Flight crew send a position report to the Aircraft Operations Centre, who forward it to Air Traffic Control.

Challenges for New Zealand

Given the impending decommissioning of the radar network and the implementation of ADS-B and related technologies, New Zealand will require standards for ADS-B equipment on board aircraft so it too can take advantage of the many benefits that flow from this versatile technology.

Challenges for operators

The introduction of ADS-B will benefit both Airways and the larger operators due to improved surveillance coverage, improved traffic flow, reduced fuel costs and reduced infrastructure costs. However, at current prices, the technology may not yet be cost effective for smaller air transport and private operators.

Installation and equipment availability issues will need to be managed, to ensure that there are adequate lead times to enable operators to install and seek approvals for equipment before the radar network is decommissioned. Installation of the new network will require careful testing and trialling to ensure that the system does not introduce safety risks.

Specific challenges apply to operators where practicality also presents a challenge - for example–gliders, hang gliders, balloons and other recreational aircraft where weight or panel space presents added difficulty.

Decommissioning the radar network

With the proposed decommissioning of the radar network by 2021, an alternate option will need to be implemented for surveillance. Decommissioning of major infrastructure also presents its own technical challenges, and will need careful management.

Fail-safe systems

While the ADS-B receiver network will enable wider and cheaper coverage than the radar network, ADS-B relies on accurate GNSS position information. A GNSS failure, while extremely unlikely, must be taken into account, and some ground-based surveillance may be required to ensure that the system remains resilient

Clarity on standards

Clarity on standards for ADS-B equipment and associated GNSS receivers is required quickly to provide certainty to operators interested in early uptake of the technology.

Procedural and training needs

New technology brings with it the need for new procedures and training. Maintenance and operator procedures will need updating, while pilots and air traffic controllers will need to be trained.

Discrete operations

ADS-B technology involves transmission of precise identification, position and trajectory data by an aircraft. This information can be picked up by any person with an ADS-B receiver. Consideration will need to be given to the need for shielding of covert defence or police operations that need to remain undetected.

Incursions

Removal of the radar network will also remove the current ability to detect incursions into controlled airspace if the offending aircraft is not transponding. This can cause issues, particularly at international airports. Some ability to detect non-ADS-B equipped or transponding aircraft may need to be retained in densely populated airspace.

Changes in regulation

New regulatory requirements will need to provide clarity on equipment, training and procedural requirements, and both the regulator and the industry will need to build capacity and understanding.

Future shifts in technology

In time, ADS-B IN, combined with advances in aircraft collision avoidance systems, may allow for further changes to service concepts, with aircraft able to be more self-managing and less reliant on air traffic control services. This is unlikely to be practical before 2023 in domestic airspace, but trials using ADS-B IN for self-separation for in-trail climb are being conducted in the Pacific, and might be introduced into the Auckland Oceanic FIR.

Multistatic Primary Surveillance Radar (MPSR) is a developing technology that uses a number of dispersed receivers to detect the reflected signals from MPSR transmitters or FM or television broadcast transmissions. The processing of these signals is similar to that employed in multilateration. MPSR is still under development, with trials under way in Europe and North America. It may offer an economical alternative to the expensive conventional primary surveillance radar.

Projected growth in remotely piloted aircraft of all sizes is expected to be significant over the next 10 years. Any changes to surveillance technology will need to be able to accommodate these aircraft.

Finally, ADS-B technology may have future potential to provide enhanced functions, such as emergency location of aircraft and operational flight tracking.

Plan for surveillance

Stage 1 2014-2015 Planning for progressive implementation of ADS-B, including rule development and training and education programme development.

Stage 2 2016-2018 ADS-B mandatory airspace above FL 245 with supporting network of ADS-B ground stations.

Stage 3 2019-2023 ADS-B mandatory in all controlled airspace from 2021 supported by back-up ground surveillance network. Some provision for controlled airspace to be designated for transit lanes and special areas for non-ADS-B equipped aircraft as per contingency plan.

Objectives

- Install a network of ADS-B ground stations to replace the radar network.
- Develop a strategy for decommissioning the radar network by 2021, ensuring that an adequate contingency surveillance network remains in place. The strategy should be completed by end 2014, consulted and:
  - Ensure that in case of a GNSS outage, all airborne aircraft can be safely recovered.
  - Ensure continuity of service can be maintained at international airports and on the main trunk routes.
- Require ADS-B equipment to be installed on aircraft in a staged way:
  - From 2018: ADS-B carriage mandatory above FL 245.
  - From 2021: ADS-B carriage mandatory in all controlled airspace.
- Develop policy to ensure smooth transition to ADS-B for smaller commercial and private operators by end 2014, taking into account the need for:
  - Management of cost and practicality issues – particularly for the recreational sector.
  - Availability and capability of engineers.
  - CAA capacity to certify aircraft equipment, operators and pilots.
  - System resilience during the transition.
  - Monitoring of ADS-B capability.
  - Ongoing monitoring of technology capability and changes.
- Implement an education programme for operators, pilots and air traffic controllers on ADS-B installation and operational requirements.
- Regulatory changes to allow implementation of ADS-B mandatory airspace and to set ADS-B avionics equipment standards – policy development should be complete by end 2014 to include:
  - Clear standards for ADS-B equipment - based on 1090 Mode S Extended Squitter.
  - Provision for discrete Police and Defence operations.

Principles

- Allow time for general aviation operators to meet requirements and for equipment prices to reduce.
- All new technology installation meets safety standards that either maintain or improve on existing safety requirements.
- Implementation of ADS-B aligns with timeline for Performance Based Navigation.

Surveillance actions

Key Objectives	Stage 1 2014-2015 Planning for progressive implementation of ADS-B.	Stage 2 2016-2018 ADS-B mandatory airspace above FL 245 and CTA or major international airports.	Stage 3 2019-2023 ADS-B mandatory in all controlled airspace. Contingency surveillance network in place.
Develop a strategy for decommissioning the radar network by 2021, ensuring that an adequate network of back-up surveillance remains in place.	Contingency strategy developed to ensure fail-safe surveillance system by end 2014 to: • Ensure that in case of a GNSS outage, all airborne aircraft can be safely recovered. • Ensure continuity of service can be maintained at international airports and on the main trunk routes.	Contingency strategy implemented.	By 2021 some legacy radar remains, or alternate installed at strategic points in accordance with contingency plan.
Install network of ADS-B receivers to replace radar network.		ADS-B ground infrastructure in place to provide coverage above FL245.	ADS-B ground infrastructure provides coverage of all controlled airspace.
Require ADS-B equipment to be installed on aircraft in a staged way.		Approved ADS-B equipment required in all aircraft operating above FL245.	Approved ADS-B equipment required in all controlled airspace.
Implement an education programme for operators, pilots and air traffic controllers on future ADS-B installation and operational requirements.	Operator procedure guidelines developed. Education programme for operators, pilots and air traffic controllers on ADS-B installation, and operational requirements. Training standards updated.	Training requirements for use of ADS-B equipment included in training curriculum.	
Develop policy and rules to allow progressive implementation of ADS-B airspace.	Develop and implement policy to ensure smooth transition to ADS-B by end 2014, taking into account the need for: • Management of cost and practicality issues for smaller commercial and private operators. • Availability and capability of engineers. • CAA capacity to certify aircraft equipment, operators and pilots. • System resilience during the transition. • Monitoring of ADS-B capability. • Rule development – timelines and specifications for equipage and operator requirements • ADS-B equipment standard: 1090 Mode S Extended Squitter. • Provision for discrete Police and Defence operations.	Review of technologies, including multistatic primary surveillance radar and options for self-surveillance using ADS-B IN.	

Communications
Incremental improvements

Introduction

Communications play a vital role in air navigation. They provide the contact between the aircraft and the ground that keeps aircraft safe, ensures efficient aircraft flow, and provides the aeronautical and weather information that enables good decision-making.

Ground communications link Air Traffic Service facilities, both domestically and internationally, and also provide the networks for the distribution of aeronautical and meteorological information.

Radio communications

Early aviation communication was achieved using signalling techniques, such as flags and flares. By the 1930s, radio communications had become essential to aviation safety and efficiency, with ICAO's predecessor, the International Commission for Aerial Navigation, agreeing that all aircraft with 10 or more passengers should carry radio.

Voice radio communications between air and ground generally use the very high frequency (VHF) range, with some use of high frequency (HF) used for oceanic and remote continental flights. **Satellite voice communication (SATVOICE)** has been available since the early 1990s, but its use in aviation is limited at present. one hundred years on from its initial Introduction, radio voice communication is being supplemented by digital data communications to enhance over-the-horizon communications and to make more efficient use of the limited radio spectrum available.

Data-link communications

Digital data-link technology has made a significant change to aviation communications, particularly in remote and oceanic airspace.

Automatic Dependent Surveillance-Contract (ADS-C) is a system for automated aircraft position reporting by data-link. Reports are sent at specified intervals, or events, in accordance with a 'contract' set by the air traffic service provider during the ADS-C log-on process.

Controller-Pilot Data-Link Communications (CPDLC) is used to send standard messages between aircraft and air traffic controllers. CPDLC does not yet provide the almost instantaneous communication of VHF voice and is mainly used for oceanic and remote continental operations.

Within most regions, except Europe, the data-link process is known as FANS 1/A and is based on the Aircraft Communication Addressing and Reporting System (ACARS). Within the EU, the Baseline 1 ATN-based system is used (see definitions below). Both use the Inmarsat satellite network, with some use of the MTSAT (Multifunctional Transport Satellites) and Iridium networks.

The Introduction of IP (internet protocol)-based networks for data-link systems is likely to reduce communications costs. Implementation is unlikely before 2015.

Ground-ground communications

Ground-ground communications are also undergoing change. Over the next five years, the Aeronautical Fixed Telecommunication Network (AFTN) will be replaced by the **ATS Message Handling System (AMHS).** The AMHS will form the basis for the **Aeronautical Telecommunication Network (ATN),** which will be the new standard for transfer of information in the future. The ATN will use more modern protocols and be capable of handling longer messages at higher speeds than the AFTN.

International developments

Air-ground communications

Given current technology, the following trends in aviation communication are likely during the period of this Plan, as recognised in the ICAO Global Air Navigation Plan (see Table 3):

- VHF voice communications will remain the primary method of communication in non-remote continental airspace.
- The use of data-link within non-remote domestic airspace is unlikely, except within Europe.
- Use of HF voice communications will decline, replaced to some extent by SATVOICE (satellite phone technology).
- Internet protocol (IP) capability is likely to be introduced.
- In the longer term, digital radio may be introduced for air-ground voice communications.
- In the very long term, the difference between communications and surveillance will become blurred as technology is introduced to enable information sharing between aircraft and air traffic management.
- Internationally, the following changes in technology are occurring:
  - Europe is implementing ATN Baseline 1 CPDLC data-link services. The ATNB1 package is currently being deployed in 32 European flight information regions above FL285. The new requirement mandates the carriage of ATN-B1 equipment by aircraft above FL 285 from February 2015.
  - The USA will introduce departure clearances using FANS 1/A+ in 2014.

The worldwide use of data-link is set to increase as more states adopt the technology. The development of ATN Baseline 2 as the replacement for FANS 1/A will take place over the next few years.

FANS (Future Air Navigation System) FANS 1/A is the system by which CPDLC and ADS-C messages are carried within the ACARS message framework.

ACARS (Aircraft Communications Addressing and Reporting System) is a messaging protocol that was designed by a communications service provider, ARINC, to replace its VHF voice service in 1978. It uses telex formats. Another communications provider, SITA, later added an ACARS capability to its worldwide network.

ATN (Aeronautical Telecommunications Network) is a global internet work architecture that allows ground, air-ground and avionic data sub-networks to exchange digital data. Over the next 20 years, ACARS will be superseded by the more efficient and secure ATN protocol for ATC and airline communications.

AFTN (Aeronautical Fixed Telecommunication Network) is a worldwide system of aeronautical fixed circuits for the exchange of messages and digital data between aviation users. The system carries distress, urgency, flight safety, meteorological, flight regularity and aeronautical administrative messages.

Ground-ground communications

ICAO is promoting the transition from the Aeronautical Fixed Telecommunications Network (AFTN) to the Aeronautical Message Handling System (AMHS). The AMHS is a pre-cursor to the Aeronautical Telecommunications Network (ATN).

Current status in New Zealand

Aeronautical communications fall within the Aeronautical Fixed Service (AFS), the Aeronautical Mobile Service (AMS) and the Aeronautical Mobile Satellite Service (AMSS).

The two mobile services include the Route services – AM(R)S and AMS(R)S. These are reserved for communications relating to regularity and safety of flights. All Air Traffic Service communications are Route services, as are most airline operational control (AOC) communications. Off-route (OR) services are intended for non-safety communications, such as flight coordination and airline administration control.

Table 3: ICAO block upgrades related to communicaion

	Block 0	Block 1	Block 2	Block 3
Improved Safety and Efficiency through Data-Link (TBO)	Initial set of data-link applications for surveillance and communications in air traffic control.	Improved synchronisation of traffic flows at en-route merging points, and optimisation of approach sequence through the use of 4D TRAD* capability and airport applications (e.g. D-Taxi) via the air-ground exchange of data related to a single controlled time of arrival.		Trajectory-based operations deploys an accurate four-dimensional trajectory that is shared among all of the aviation system users and provides consistent and up-to-date information system-wide, which is integrated into decision-support tools facilitating global ATM decision-making.
Remotely Piloted Aircraft Systems (RPA)	Allow climb and descent procedures using ADS-B – prevents aircraft being trapped at a sub-optimal altitude and reduces fuel burn.	Initial integration of Remotely Piloted Aircraft (RPA) Systems into non-segregated airspace. Implementation of basic procedures for operating RPA in non-segregated airspace including detect and avoid.	RPA integration in traffic implements refined operational procedures that cover lost link (including a unique squawk code for lost link), as well as enhanced detect and avoid technology.	RPA transparent management. RPA operate on the aerodrome surface and in non-segregated airspace, just like any other aircraft.

*4D trajectory management is expected to improve air traffic operations, in particular to increase the overall predictability of traffic. The operator and service provider agree a target time of arrival over a waypoint of the trajectory, within a set tolerance.

Fixed services

ATS direct speech circuits: Air Traffic Service direct speech circuits provide direct voice communications between air traffic units, both domestically and internationally. These are typically used for coordination of traffic.

Ground-ground messaging: The Aeronautical Fixed Telecommunication Network (AFTN) provides for the exchange of messages or data between stations. Its uses include passing flight plan and AIDC (air traffic control interfacility data communications) messages and disseminating NOTAM (Notices to Airmen). New Zealand is connected to the international network through Airways' Christchurch Centre and the Brisbane and Salt Lake City Communication Centres.

The Aeronautical Message Handling System (AMHS) will replace the Aeronautical Fixed Telecommunications Network (AFTN) as the means of exchanging messages by 2016.

AIDC coordination messages and meteorological messages are carried over the AFTN, and will also transition to the AMHS.

Mobile services: The AM(R)S is used for voice communications between aircraft and Air Traffic Service units and for some airline operational control (AOC) communications. Most AM(R)S uses VHF frequencies between 118 and 130 MHz, though a number of HF frequencies are used where there is no VHF coverage (for example, on oceanic routes). Airways has an extensive network of VHF facilities across the country and HF facilities at Auckland, while various air operators provide facilities for AOC.

Air-ground voice communications: The AM(R)S is used for voice communications between aircraft and Air Traffic Service units and for some airline operational control (AOC) communications. Most AM(R)S uses VHF frequencies between 118 and 130 MHz, though a number of HF frequencies are available where there is no VHF coverage (for example, on oceanic routes). Airways has an extensive network of VHF facilities across the country and HF facilities at Auckland, while various air operators provide facilities for AOC.

The AM(OR)S is generally used for airline administrative communications on frequencies between 130 and 137 MHz or at HF, with ground facilities provided by the air operators.

There is some use of the AMS(R)S for SATVOICE communications, though at present this is limited to urgent, non-routine communications.

Air-ground data communications: The AM(R)S and AMS(R)S are also used for data-link communications, for both ATS and AOC purposes. These data-link services are generally provided by communication service providers, such as ARINC and SITA.

Most data-link traffic is carried in the AMS(R)S. The main uses are oceanic controller-pilot data-link communications (CPDLC) and automatic dependent surveillance-contract (ADS-C). Air operators also use data-link for aeronautical operational control (AOC).

Currently, CPDLC and ADS-C follow the FANS 1/A protocols and are carried via the Aircraft Communications and Reporting System (ACARS).

Challenges for New Zealand

Most changes in the communications area on the horizon are related to improvements in the technology such as the transition to AMHS, and then to the ATN protocol.

However, there are some technologies that may have more direct implications for operators in the longer term, including data-link systems and Remotely Piloted Aircraft.

High frequency radio

High frequency radio is not an ideal communications medium, and many newer aircraft are already equipped with satellite communications (SATVOICE). New Zealand does not yet permit SATVOICE as a primary means of communication, though this is likely to change as SATVOICE technology improves and becomes more economical.

Volume of air traffic in New Zealand

The volume of traffic in New Zealand is not significant, and even at the larger international airports at peak flow, we have not yet reached capacity with the radio communication network.

However, with the improved routing through PBN, and the proposed Introduction of an ADS-B ground network from 2018, along with improvements in traffic flow, all resulting in reduced separation requirements, the need for a more efficient communication system may become more apparent in our busier airspace.

Introduction of data-link

Technical development of data-link systems continues, with potential for interfacing with a range of other avionics systems.

While present spectrum allocations are adequate, increases in the use of data-link systems may stretch the limits of the bandwidth available for data-link via satellite. Success of aeronautical data-link systems depends upon adequate bandwidth, as well as sufficient data processing capability on the ground and in the air.

Costs associated with installation of a full data-link system in aircraft are high and certainly outside the current scope of the general aviation community. Technology costs would need to reduce significantly before data-link becomes an option for smaller operators.

International operations

New Zealand's international operators are generally equipped for CPDLC and ADS-C. However, in the future these operators may need to consider the changes proposed in Europe and the move to ATN B2. This will be especially important over the next 20 years as ACARS is superseded by the faster and more secure ATN.

Remotely piloted aircraft

One significant challenge for New Zealand is the potential increase of remotely piloted aircraft. Both data-link and voice systems will be required to ensure that they are managed effectively, especially in non-segregated airspace.

Human factors

Should New Zealand choose to introduce data-link systems into its domestic communications framework, or require changes from the international equipage requirements, the transition from a predominantly voice communication environment to a predominantly messaging environment will need to be effectively managed. This change would require a major shift in pilot, operator and air traffic controller behaviour and training, as well as the development of new procedures to maintain a safe operating environment for all.

Back-up systems

As with any new technology implementation, fail-safe systems will always be needed. Given current technology development, a dual voice or data-link combination is still likely to be required.

Plan for communications

Stage 1 2014-2015 Ongoing maintenance of the VHF network. Complete transition from AFTN to AMHS. Develop policy for Remotely Piloted Aircraft communications.

Stage 2 2016-2018 Introduce international pre-departure clearances via data-link and review demand for additional use of data-link technology. Introduce Voice over IP for linking to remote sites and for ground communication. Transition to ATN. Implement Remotely Piloted Aircraft Policy.

Stage 3 2019-2023 VHF voice communication remains the primary means of communication in domestic airspace. Implement results of review on data-link technology. Approve SATVOICE as a primary means of voice communication in oceanic controlled airspace.

Objectives

- VHF voice will continue as the primary communication medium in domestic airspace.
- Introduce further options for aircraft operating in oceanic airspace: Implement Baseline 2 (using ATN) in parallel with FANS 1/A.
- Implement policy for remotely piloted aircraft to ensure full integration with other aircraft in non-segregated airspace.
- Develop new protocols for communications.
  - Complete transition from AFTN to AMHS and then to ATN.
  - Introduce Voice over IP (VOIP) for linking to remote sites and for ground communication.
- Review demand for data-link in the domestic environment-including:
  - Aerodrome Mobile Airport Communication System (AeroMACS).
  - L-Band Data-link Aeronautical Communications System (LDACS).
- International pre-departure clearances via data-link (ARINC 623) from 2014.
- Accept SATVOICE as a primary voice communication medium in oceanic controlled airspace.

Principles

- Closely follow other countries' leads in this area.
- Take into account likely developments in data-link systems, and ensure that any New Zealand implementation provides maximum economic and safety benefits.
- There is sufficient availability of radio frequency spectrum.
- Consider costs carefully prior to implementing any new communications requirements.
- Take account of remotely piloted aircraft.
- Ensure changing systems do not increase the workload of pilots and air traffic controllers.

Communications actions

Key Objectives	Stage 1 2014-2015 *Business as usual, with a transition from AFTN to AMHS.*	Stage 2 2016-2018 *Introduction of some new protocols, methods and technologies.* *Review demand for data-link technology in domestic airspace.*	Stage 3 2019-2023 *Transition to ATN.* *Accept SATVOICE for primary voice communications.* *Implement results of review on data-link technology.*
VHF voice to continue as the primary communication medium in the domestic environment.	Ongoing maintenance of the VHF network.	Ongoing maintenance of the VHF network.	Ongoing maintenance of the VHF network.
Additional options for oceanic airspace aircraft equipped with FANS1/A data-link.	Continue to use CPDLC as primary oceanic communication media via VDL and SATCOM (and HFDL).		Implement Baseline 2 (using ATN) in parallel with FANS 1/A.
Communications policy for Remotely Piloted Aircraft.	Develop policy for Remotely Piloted Aircraft.	Remotely Piloted Aircraft: All data-link and voice CNPC in non-segregated airspace must operate within the AM(R)S or AMS(R)S.	
Develop new protocols.	Complete transition from AFTN to AMHS.	Implement ATN. Introduce Voice over IP (VoIP) for linking to remote sites and ground communication.	Complete transition from AMHS to ATN.
Introduce and review demand for additional communication methods – SATVOICE and data-link.		International pre-departure clearances via data-link (ARINC 623) from 2014. Review demand for data-link in the domestic environment, including for: Aerodrome Mobile Airport Communication System (AeroMACS). L-Band Data-link Aeronautical Communications (LDACS).	Oceanic: SATVOICE supersedes HF as primary voice system. Implement results of data-link reviews.

Aeronautical Information Management **Digital and integrated**

Introduction

The Aeronautical Information Service (AIS) is still largely based on a suite of paper-based publications and charts with some online accessibility of information. It includes:

- **The Aeronautical Information Publication (AIP),** including amendments and supplements. This document contains most of the information a pilot needs about procedures and aerodromes.
- **NOTAM (Notices to Airmen):** Alerts to pilots of any hazards en-route or at a specific location.
- **Aeronautical Information Circulars (AIC):** Notices containing information that does not qualify for the origination of a NOTAM or for inclusion in the AIP, but which relates to flight safety, air navigation, technical, administrative or legislative matters.
- **Pre-flight Information Bulletins:** Summaries of the above disseminated to pilots via internet, phone or fax before a flight to assist in flight planning.

Over the next 10 years, the aviation system will become more responsive to demand, with the development of airborne navigation technology, surveillance systems and direct ground-air data-links.

To accommodate this, paper-based systems will need to progress to digital data-driven systems that allow continuous, up-to-date and real-time transfer of the full range of aeronautical information to all participants in the aviation system, in the air and on the ground.

ICAO calls this the transition from aeronautical information services (AIS) to aeronautical information management (AIM).

International developments

The provision of aeronautical information today is mainly focused on the requirements for the Aeronautical Information Publication, aeronautical charts and for pre-flight briefing.

In the future, aeronautical information provision will address the requirements of all components of the aviation system for all phases of flight. The timely availability of high-quality and reliable aeronautical, meteorological, airspace and aerodrome information is a critical pre-requisite for the development of the many new tools that future aviation systems will employ to enable a collaborative, interoperable and flexible decision-making environment.

There is an international drive to transition aeronautical information services to a digitalised and holistic information management system covering all aspects of aviation information management. The two related elements in the ICAO Global Air Navigation Plan (Doc 9750) are set out in Table 4.

Table 4: ICAO block upgrades related to aeronautical information

	Block 0	Block 1	Block 2	Block 3
Digital Aeronautical Information Management (DATM)	Development of a single source database (Aeronautical Information Exchange Model AIXM), Introduction of an electronic Aeronautical Information Publication (AIP) and better quality and availability of data.	All digital information will be integrated using standardised data protocols.		
Application of System Wide Information Management (SWIM)*		Development of a common aviation intranet to share all available information, and connection of this intranet direct into aircraft. Information in this system will include airport operational status, weather information, flight data and status of special use airspace.	Enabling airborne participation in collaborative ATM through SWIM connection of the air craft and information node in SWIM enabling participation in collaborative ATM processes with access to rich voluminous dynamic data, including meteorology.	

*SWIM is intended internationally to be a cornerstone of future developments in aeronautical information, but work is still under way in international bodies to agree on SWIM definitions, concepts and potential solutions.

ICAO has also developed a roadmap for the international transition to aeronautical information management. New Zealand is making good progress to date as set out in Table 5 below. The transition to AIM will not involve many changes in terms of the scope of information to be distributed but rather the method of delivery and access. The major change will be the increased emphasis on information management and real-time data distribution.

Table 5: New Zealand AIS to AIM implementation progress

	Roadmap steps	Deadline	NZ status
Phase 1 Consolidation	P-03 — AIRAC adherence monitoring		Complete
	P-04 — Monitoring of States' differences to Annex 4 & 15		Complete
	P-05 — WGS-84 implementation		Complete
	P-17 — Quality		Complete
Phase 2 Going digital	P-01 — Data quality monitoring		Complete
	P-02 — Data integrity monitoring		Complete
	P-06 — Integrated aeronautical information database		Complete
	P-07 — Unique identifiers		Complete
	P-08 — Aeronautical information conceptual model (AICM)*	2015	Near Complete
			Complete
	P-11 — Electronic AIP	2015	In Progress
	P-13 — Terrain	2015	In Progress
	P-14 — Obstacles	2015	In Progress
	P-15 — Aerodrome mapping		
Phase 3 Information management	P-09 — Aeronautical data exchange	2010-2018	In Progress
	P-10 — Communication networks	2011-TBA	In Progress
	P-12 — Aeronautical information briefing	2015	In Progress
	P-16 — Training	2015	In Progress
	P-18 — Agreements with data originators	2013	Near Complete
	P-19 — Interoperability with meteorological products	2018+	In Progress
	P-20 — Electronic aeronautical charts	2018+	In Progress
	P-21 — Digital NOTAM	2014-2018	In Progress

***AIXM Conceptual Model** provides a formal description of the aeronautical information items, using a standard data modelling language.

Status of aeronautical information management

The gathering and dissemination of aeronautical information is governed by ICAO Annex 15 and Annex 4. This defines how an aeronautical information provider should receive and/or originate, collate or assemble, edit, format, publish, store and distribute specified aeronautical information and data.

In New Zealand, these requirements are reflected in Rule Part 175 requirements and delivered by Airways, under contract to the Civil Aviation Authority.

New Zealand has completed the development of the New Zealand Plan for the Transition from AIS to AIM in accordance with the ICAO Roadmap for the transition from AIS to AIM (2009).

The current aeronautical information service (AIS) is a mix of paper-based and electronic processes and products. This mixed-modal approach is supported by:

- **A single source database:** New Zealand has completed the migration of all static aeronautical information to a single database that is compliant with international standards (the ICAO mandated aeronautical information exchange model – AIXM).
- **Online information:** New Zealand currently makes both the Aeronautical Information Publication New Zealand (AIPNZ) and Notices to Airmen (NOTAM) information available via web browsers. The AIPNZ is available in PDF format on the AIPNZ website. NOTAM/Briefing information is available via HTML on Airways Internet Flight Information Service (IFIS).
- **Replacement of legacy systems with digital solution:** Airways is undertaking a lifecycle replacement programme for its legacy NOTAM/Briefing system. The legacy system will be replaced with a digital solution that is compatible with the single source database AIXM in 2014.
- **Electronic terrain and obstacle data (eTOD):** Area 1 terrain data is currently available from the state topographic mapping agency, Land Information New Zealand. A system of collation and promulgation of Area 2, 3, and 4 eTOD is being developed and finalised. Aerodrome operators are being made aware of obstacle survey requirements for eTOD as required by Annex 15.

As a Part 175 certificate holder, Airways operates an ISO 9001 certificated quality management system that covers the full range of operational activities, including aeronautical information services. Originators of data are required to confirm data integrity upon submission and also annually confirm that data published by them is correct and up-to-date.

Challenges for New Zealand

In New Zealand, progress is already being made towards a transition to aeronautical information management. Challenges in AIM implementation in New Zealand include:

System wide information management (SWIM)

There are significant issues associated with resolving the institutional and legal issues that encompass, among others, organisational, financial and intellectual property aspects associated with the system-wide management of aeronautical information.

Rapid technological change

Outside the ICAO requirements, there is a proliferation of technology-based products that can be used for aviation purposes but are non-traditional in nature or provided by non-certificated or non-aviation organisations. A key question for New Zealand relates to what products should be provided outside the ICAO requirements, and who should provide them.

Technology is advancing faster than aeronautical information management can adapt, especially in areas of non-Annex 15 aeronautical data and non-air transport operations. For example, the provision of aeronautical charting in digital form may be suitable for flight management systems, but not for individual pilots who want applications on smart phones, hand-held computers and tablet devices. This is an area that must be monitored and solutions assessed as appropriate.

Assurance of quality and integrity of data

Moving to a data-centric system, as distinct from product-centric, requires assurance of quality and integrity of data before and when it gets to the end-user. There is already a lot of information that is accessible but not necessarily to a standard suitable for regulated safety systems (e.g. third party products). A key part of the information management system might be to manage non-certified aeronautical information/data that can potentially affect the safety of air navigation.

Human factors

Evolution from paper-based systems to computerised data-based systems will occur over an extended period, with present and future styles of operation proceeding in parallel. Changing the presentation and source of information will bring its own challenges, and will necessitate new skill development for all groups of users, from pilots to air traffic controllers to staff involved in producing the information.

Maintenance of data

It will be increasingly necessary in a digital and real time environment to ensure ongoing maintenance of data to ensure it is accurate and up-to-date.

Plan for aeronautical information

Stage 1 2014-2015 Going digital: Complete transition from AIS to AIM in accordance with ICAO roadmap.

Stage 2 2016-2018 Integration of data and systems.

Stage 3 2019-2023 Real time availability of data into aircraft.

Objectives

- Complete digitalisation of information in accordance with the ICAO roadmap:
  - P-08 — Aeronautical information conceptual model
  - P-14 — Obstacles
  - P-15 — Aerodrome mapping
  - P-20 — Electronic aeronautical charts
- Ensure information management is integrated in accordance with ICAO roadmap:
  - P-09 — Aeronautical data exchange
  - P-10 — Communication networks
  - P-12 — Aeronautical information briefing
  - P-16 — Training
  - P-18 — Agreements with data originators
  - P-19 — Interoperability with meteorological products
  - P-21 — Digital NOTAM
- New digital aeronautical data accessible to all participants in the system – with a focus on:
  - Real-time availability of data, both on the ground and in the air.
  - Manage human factors associated with accessibility of data on new applications and devices.

Principles

- Guided by the Global Air Navigation Plan (Doc 9750) and ICAO Roadmap.
- Data is accurate and reliable and scalable.
- Keep any required equipment upgrade costs to a minimum by building on existing developments.
- Limit any disruption to supporting systems and infrastructure network is mitigated.

Aeronautical information actions

Key Objectives	Stage 1 2014-2015 *Going digital: Complete transition from AIS to AIM in accordance with ICAO roadmap.*	Stage 2 2016-2018 *Integration of data and systems.*	Stage 3 2019-2023 *Real time availability of data into aircraft.*
Start digitalisation of remaining information domains in accordance with the ICAO roadmap.	Ongoing maintenance of the VHF network.	Ongoing maintenance of the VHF network.	Ongoing maintenance of the VHF network.
Ensure information management is integrated in accordance with ICAO roadmap.	Continue to use CPDLC as primary oceanic communication media via VDL and SATCOM (and HFDL).		Implement Baseline 2 (using ATN) in parallel with FANS 1/A.
Make digital aeronautical data accessible to all participants in the system.	Develop policy for Remotely Piloted Aircraft.	Remotely Piloted Aircraft: All data-link and voice CNPC in non-segregated airspace must operate within the AM(R) S or AMS(R)S.	
Manage human factors associated with data availability.	Complete transition from AFTN to AMHS.	Implement ATN. Introduce Voice over IP (VoIP) for linking to remote sites and ground communication.	Complete transition from AMHS to ATN.

Air Traffic Management (ATM) From controlling to enabling

Introduction

In the other elements of this Plan, we have explored the potential of future technologies to improve the efficiency and safety of airspace use – including performance-based navigation through access to satellite technology, more accurate position reports through ADS-B, faster and better quality communications, more integrated and better quality information, and streamlining of airspace design in response to demand.

Central to all of these new technologies is the presence of air traffic control – the current single coordination point for all air and ground operations.

Early air traffic control tools were simple: a red flag for "hold" and a checked one for "go".

By World War II, air traffic controllers were already relying on the integration of a mix of different technologies to identify the position of the aircraft (radar), communicate with the pilots (radio) and collect the information they needed to be able to direct traffic to their intended destination.

Then came progress in surveillance by combining radar and radio communications with integrated air traffic control networks. Modern systems utilise computer systems, digital equipment and modern CNS (communications, navigation and surveillance) to provide a complete air traffic management service.

This chapter examines the role that this service will play in the future, and the tools that can be employed to improve the flow of air traffic and ensure safety as our skies become busier.

International developments

The modern vision for the Air Traffic Management (ATM) system is based on the provision of services with a view to becoming air traffic-enabling rather than air traffic-controlling.

This service-based framework considers all resources to be part of the ATM system, including airspace, aerodromes, aircraft, and humans. An ATM system functions through the collaborative integration of humans, information, technology, facilities and services, supported by air, ground and/or space-based communications, navigation and surveillance.

Air Traffic Management (ATM), is defined by the International Civil Aviation Organization (ICAO) as:

> *"The dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management — safely, economically and efficiently — through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions."*

A large number of the block upgrades contained in ICAO's Global Air Navigation Plan are designed to provide a pathway to an enabling integrated air traffic management system (see Table 6). A modern air traffic management system includes increased integration of air traffic control information tools for air traffic controllers to manage traffic flows.

These tools bring together many of the technologies discussed in previous chapters to provide core outcomes for future airspace management – less delay, greater efficiency, better coordination and collaboration and improved safety and environmental benefits.

Table 6: ICAO block upgrades related to air traffic management

	Block 0	Block 1	Block 2	Block 3
Increased runway throughput through optimised wake turbulence separation (WAKE)	Revision of current ICAO wake vortex separation, minima and procedures.	Dynamic wake turbulence separation – based on real-time identification of wake vortex hazards.	Advanced (time-based) wake turbulence separation – time based aircraft to aircraft wake separation, and changes to the procedures the service provider applies to the wake separation minima.	
Improved traffic flow through sequencing (AMAN/ DMAN) – (RESQ)	Time-based metering to sequence departing and arriving aircraft.	Integration of surface management with departure sequencing to improve efficiency.	Synchronised AMAN/ DMAN to promote more agile and efficient en-route and terminal operations.	Fully synchronised network management between departure airport and arrival airports for all aircraft in the air traffic system at any given point in time.
Increased interoperability, efficiency and capability through ground-ground integration (FICE)	Supports the coordination of ground-ground data communication between ATSU based on inter-facility data communication AIDC defined by ICAO Doc 9694.	Introduction of FF-ICE[6] Step One, to implement ground-ground exchanges using common flight information reference model FIXM, XML and the flight object[7] used before departure.	Improved coordination through multi-centre ground-ground integration (FF-ICE, Flight Object, SWIM) – FF-ICE supports trajectory-based operations through exchange and distribution of information for multi-centre operations using flight object implementation and IOP standards.	Improved operational performance through the introduction of full FF-ICE – all data for all relevant flights systematically shared between air and ground systems using SWIM in support of collaborative ATM and trajectory-based operations.
Improved operations through enhanced en-route trajectories (FRTO)	Allow the use of airspace which would otherwise be segregated (e.g. military) along with flexible routing adjusted for specific traffic patterns.	Introduction of free routing in defined airspace where the flight plan is not defined as segments of a published route network or track system to facilitate adherence to the user preferred profile.		Introduction of complexity management to address phenomena that affect traffic flows due to physical limitations, economic reasons by exploiting SWIM.
Improved flow performance through planning based on a network-wide view (NOPS)	Collaborative ATFM measure to regulate peak flows involving departure slots managed rate of entry into a given piece of airspace for traffic along a certain axis, requested time at a way-point of an FIR/sector boundary along the flight, use of miles in trial to smooth flows along a certain traffic axis and rerouting of traffic to avoid saturated areas.	AFTM techniques that integrate the management of airspace, traffic flows, including initial user-driven prioritisation processes for collaboratively defining ATFM solutions based on commercial/ operational priorities.	Introduction of CDM applications supported by SWIM that permit airspace users to manage competition and prioritisation of complex ATFM solutions when the network or its notes no longer provide capacity commensurate with user demands.	

	Block 0	Block 1	Block 2	Block 3
Air traffic situational awareness (ATSA)	ATSA applications that provide pilots with the means to achieve quicker visual acquisition of targets (AIRB and VSA).	Interval management improves the management of traffic flows and aircraft spacing, precise management of intervals between aircraft with common or merging trajectories maximises airspace throughout while reducing ATC workload along with more efficient fuel burn.	Creation of operational benefits through temporary delegation of responsibility to the flight deck for separation provision with suitably equipped designated aircraft (likely ADS-B IN) – thus reducing the need for conflict resolution clearances while reducing ATC workload.	
Ground-based safety nets (SNET)	Assisting the air traffic controller and generating alerts of an increased risk to flight safety e.g. short term conflict alert, area proximity warning minimum safe altitude warning.	Reducing the risk of controlled flight into terrain accidents by using Approach Path Monitor.		
Remotely operated air traffic service (RATS)		Remotely operated Aerodrome Control Tower contingency and remote provision of ATS to aerodromes through visualisation systems and tools.		
Airborne collision avoidance system (ACAS)	ACAS improvements. To provide short term improvements to existing airborne collision avoidance systems (ACAS) to reduce nuisance alerts while maintaining existing levels of safety. This will reduce trajectory perturbation and increase safety in cases where there is a breakdown of separation.		New Collision Avoidance System implementation. Airborne Collision Avoidance System (ACAS) adapted to trajectory-based operations with improved surveillance function supported by ADS-B aimed at reducing nuisance alerts and deviations.	

6 FF-ICE Flight and Flow Information for a Collaborative Environment describes an evolution from paper-based static flight planning to a performance-based system that incorporates integrated information for flow management, flight planning, and trajectory management.

7 The 'Flight Object' (FO) is a concept to support the sharing of consistent flight data between all stakeholders. A single logical entity, the FO is kept up-to-date by all parties wishing to share information about a flight. All parties use the FO as a reference and all keep it updated with the latest information, thereby ensuring that all systems have the most up-to-date and consistent view of the flight data.

The ICAO Global ATM Operational Concept (Doc 9854) 2005 identifies seven concept components from which to base the provision of integrated services to improve traffic flow:

- **Airspace organisation and management**–dynamic and flexible to ensure that the allocation of resources, restrictions, activities and services support the traffic needs of the day. Restrictions to specific operations should be minimised to the extent possible, to ensure that the overall system is optimised.
- **Aerodrome operations**–enable the efficient use of the capacity of the aerodrome airside infrastructure. Periodic review of infrastructure and procedures with aerodrome operator to ensure maximum efficiency of available capacity and accommodate planned growth/expansion where possible.
- **Demand and capacity balancing**–enable collaborative decision-making to balance demand and capacity for the efficient management of air traffic flow within the airspace. This will be supported by the use of information on system-wide air traffic flows, weather and assets.
- **Traffic synchronisation**–support establishment and maintenance of a safe, orderly and efficient flow of air traffic, including four-dimensional trajectory controls, negotiated conflict-free trajectories, elimination of choke points and optimisation of traffic sequencing.
- **Airspace user operations**–accommodate aircraft with mixed capabilities or define minimum performance standards, while ensuring that relevant, secure and quality ATM data is fused with operational information and made available to airspace users.
- **Conflict management**–enable support of trajectory-based operations while accommodating application of varying standards, as defined by the operational needs relating to the specific body of airspace. The performance system may be developed over a period of years as capabilities improve.
- **ATM service delivery management**–address the balance and consolidation of the decisions of the various other processes/services, as well as the time horizon at which, and the conditions under which, these decisions are made.

In addition, the system must enable the exchange and management of information between the concept components to provide an integrated aviation network with secure, timely and high quality operational information available to all.

With these new tools, the air traffic management task becomes one of strategic management to ensure efficient use of airspace available, based on user preferences.

Current status in New Zealand

The remote and diverse geographic nature of New Zealand, associated with changeable environmental conditions, makes for a challenging aviation environment. Operations comprise a mixture of commercial and recreational aircraft with a broad mix of capabilities.

The CAA is designated by the Minister of Transport as the Air Traffic Service Authority. There is currently only one provider of ATC services – Airways – with responsibility for the provision of services in domestic and in oceanic airspace.

Challenges for New Zealand

Adapting to technological change

With the introduction of greater integration into data management and dissemination, performance-based navigation, and more accurate messaging to and from aircraft, aviation systems are more technology-reliant and reliable than ever before.

As is occurring worldwide, New Zealand's future air traffic control systems will need to become more sophisticated to manage technologically advanced aircraft, while also ensuring that other operations are considered and accommodated as appropriate.

Harmonised and interoperable systems

A key pre-cursor to a more enabling air traffic service in New Zealand is the completion of the integration of aeronautical data and information across various aviation systems.

Collaborative environment

Collaboration remains a key component of the developing ATM system. Changes and developments must be facilitated through a robust collaboration process so stakeholders have the opportunity to provide input; this does not mean that complete agreement is necessary. While stakeholders must have the opportunity to provide input, changes and developments will need to be agreed based on the performance of the overall system rather than individual parts.

Trajectory-based management and network management

Further work is required in the area of network management to understand how strategic management of trajectories can be carried out in practice.

The new operating environment will manage an aircraft's profile from departure gate to arrival gate, including both civil and military operations. This will require greater integration and coordination between control units.

New trajectory management tools will enable controllers to safely manage potential conflicts and provide increased efficiencies across the network. This change will require:

- Increased use of ATM system tools by controllers and pilots to manage complexity.
- Coordinated implementation of ATM support tools, with re-training of air traffic controllers to process greater amounts of information about aircraft trajectories and management.
- A clear understanding of human performance factors relating to automation.
- Contingency planning.

The ATM system will need to include robust contingency capabilities protecting against environmental, industrial and civil disturbances. These capabilities will feature:

- Safe facilitation of operations already active when the event occurs.
- The safe continuation of operations to an agreed level depending on the contingency event.
- Contingency procedures may need to constrain (or exclude) certain operations, such as flight training or general/recreational aviation activities, for a period to maintain the safety of air transport operations, depending on circumstances.

Human factors

The new tools will reduce controllers' workloads however, there will need to be new training and education for all users for the system to work effectively.

An accompanying change in the management of commercial operators to schedule their flights by arrival time, rather than departure time, may also be required.

Legal issues

There may be legal liability issues around controller use of tools providing de-confliction assurance (passive) instead of using tactical headings to ensure de-confliction (proactive).

It is important that any metrics developed be meaningful, without placing undue burden on participants in the short term, and that they are agreed by stakeholders.

Plan for air traffic management

Stage 1 2014-2015 Infrastructure, procedure and tool development towards trajectory-based management, education programmes.
Stage 2 2016-2018 Implementation of trajectory-based management tools with training and education programmes.
Stage 3 2019-2023 Trajectory-based management in place supported by integrated information and collaborative processes.

Objectives

Future air traffic management in New Zealand will move from the concept of tactical control to the concept of strategic control and enabling service provision to facilitate the safe, orderly and efficient flow of traffic.

- Further develop and implement tools, taking into account the needs of end users for:
  - Synchronised network management between departure airport and arrival airports.
  - Trajectory-based management – a shift from clearance-based to trajectory-based air traffic control, taking both operator preferences and optimal airspace system performance into consideration.
  - Conformance monitoring to provide assurance that the track and profile of the aircraft is as expected and being maintained.
  - Conflict detection using trajectory prediction and conformance monitoring technology. Conflict detection will support the controllers, forward planning – highlighting areas of risk. Assisted by ADS-B and aircraft intent data.
- Incorporate all ground and airborne aspects including:

- Communications improvements.
- More accurate real-time position reporting from aircraft equipped with ADS-B (see surveillance).
- Air traffic services standards and procedures.
- Integrated information management: better integration of all aeronautical and weather data into the ATM system.
- Airport operations: integration with ground management systems to streamline taxi and take-off operations and development of wake turbulence waiting time calculations.
- Search and rescue.
- Information technology.
- State requirements, including national security.

- Ensure that there is adequate contingency planning to enable management during failures in the Air Traffic Management System.
- Educate, train and encourage all users (controllers and operators) to operate within the developing environment.
- Develop a performance framework with a set of metrics that will provide a measure of performance of the various aspects supporting air traffic management.

Principles

- Enabling systems will be performance-based, taking a whole-of-system approach.
- Optimise the use of technology on a system-wide basis.
- Provide services within a collaborative environment – taking into account the needs of end users.

Air traffic management actions

Key Objectives	Stage 1 2014-2015 *Infrastructure, procedure and tool development towards trajectory-based management, education programmes.*	Stage 2 2016-2018 *Implementation of trajectory-based management tools with training and education programmes.*	Stage 3 2019-2023 *Trajectory-based management in place supported by integrated information and collaborative processes.*
Further develop tools – taking into account the needs of end users.	Development of trajectory-based management and network management tools for air traffic controllers. Network-wide management principles and agreements in place.	Implement hardware and systems for trajectory-based management. Virtual air traffic control testing.	Virtual air traffic services in place at selected locations.
Incorporate all ground and airborne aspects.	Ensure that ATM systems cater for developments in the other Plan elements.		
Ensure that there are adequate contingencies to enable management during failures in the Air Traffic Management System		Contingency plan for air traffic management emergency situations amended given Introduction of new management systems.	
Educate, train and encourage all users (controllers and operators) to operate within the developing environment.	Education programme on upcoming changes to air traffic management.	Human factors assessment to ensure transition to time-based trajectory management and full network management complexities are fully assessed.	
Develop a performance framework.	Develop a set of metrics that will provide a measure of performance of the various aspects supporting air traffic management.	Review of performance of Air Traffic Management System.	Review of performance of Air Traffic Management System.

Airspace Design
Review and refine

Introduction

Over the years, to facilitate the flow of traffic and to keep certain types of air traffic away from each other, a system has been developed that distinguishes between areas of airspace that are controlled, and areas that are uncontrolled.

Controlled airspace is established to protect the flight paths of IFR flights, mainly in high volume traffic areas.

Airspace is classified under the International Civil Aviation Organization (ICAO) airspace classification system. This system determines the level of Air Traffic Service (ATS) that will be provided, and whether entry to that airspace requires an ATC clearance.

This level of service cannot be varied by ATC for any given class of airspace. There are seven classes of airspace; New Zealand currently uses four of these:

- Class A: IFR flights only are permitted, all flights are provided with air traffic control service and are separated from each other.
- Class C: IFR and VFR flights are permitted, all flights are provided with air traffic control service and IFR flights are separated from all other flights. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights.
- Class D: IFR and VFR flights are permitted and all flights are provided with air traffic control service, IFR flights are separated from other IFR flights and receive traffic information in respect of VFR flights, VFR flights receive traffic information about all other flights.
- Class G: IFR and VFR flights are permitted and receive flight information service if requested.

There are also types of special use airspace covering restricted areas, military operating areas (MOA), danger areas, volcanic hazard zones (VHZ), mandatory broadcast zones (MBZ), and low flying zones (LFZ).

International developments

ICAO does not include any specific changes in its Global Air Navigation Plan around amendments to airspace design.

However, with the Introduction of performance-based navigation, a number of countries are reviewing their airspace to take the new route structures into account. Eurocontrol, for example, is reviewing its airspace structures to provide a more streamlined route structure and airspace design (Single European Sky).

On the long term horizon, it is possible that greater use of self-controlling technologies may require less input from air traffic controllers, thus reducing the volume of controlled airspace.

Status of New Zealand airspace design

The CAA is designated by the Minister of Transport as the Airspace Authority and is responsible for the regulatory control and management of New Zealand airspace. New Zealand is also responsible for a large area of international airspace covering the southern South Pacific and the Auckland Oceanic Flight Information Region (FIR).

Civil Aviation Rule Part 71 empowers the Director to designate and classify airspace within the territorial limits of New Zealand, and airspace for which New Zealand has accepted responsibility under international civil aviation agreements. At present this covers the Auckland Oceanic Flight Information Region and the New Zealand Flight Information Region. The Director may also restrict aviation activity by the designation of special use airspace.

Rule 71.11 requires that, at intervals of 'at least every five years, the Director must review each current airspace designation and classification to verify the continuing need for the airspace designation or classification'.

An airspace review is currently under way–each region is undergoing a full review. The reviews are aligned with the introduction of performance-based navigation routes across the country. The net result of the reviews is likely to be a reduction in some areas of controlled airspace to reflect the efficiencies and accuracy being implemented in the navigation, air traffic management and surveillance areas.

New Zealand's airspace

Controlled airspace is designated where there is a need for an air traffic control service to be provided for the safety and efficiency of aircraft operations. Such designations include:

Control areas (CTA): terminal control area (TMA), upper control area (UTA) or oceanic control area (OCA). At present, only the specification OCA is used within the New Zealand FIR and Auckland Oceanic FIR although the other terms are permitted within Part 71.

Control zones (CTR) the controlled airspace designations do not include all the types of control areas and other airspace that are detailed within the ICAO SARPs and PANS-OPS documents, such as upper flight information regions (UIR) and aerodrome traffic zones (ATZ).

VFR transit lanes or general aviation area: areas within control areas or control zones may be designated as VFR transit lanes or general aviation areas (GAA). These designations are unique to New Zealand, and when active, render portions of the CTR or CTA as Class G uncontrolled airspace[8].

Special use airspace is designated where there is a need to impose limitations on the operation of aircraft for aviation safety and security, or national security, or for any other reason in the public interest.

Part 71 does not include provision for the designation of prohibited airspace as defined by ICAO.

Miscellaneous airspace designations include visual reporting points, area QNH zones and mountainous zones. The mountainous zones were designated in the 1960s and have not been reviewed since then.

Non-designated airspace descriptors in New Zealand include parachute landing areas and common frequency zones.

Transponder mandatory airspace may only be designated within controlled or special use airspace.

Challenges for New Zealand

With the changes signalled in other parts of this plan, it is clear that New Zealand's airspace design will need to be reviewed to accommodate increasing traffic, new types of aircraft and more direct and efficient flight paths.

Performance-based navigation routes

The major technological change affecting airspace design in recent years has been the shift from the use of ground-based aids for air navigation to space-based (GNSS) aids resulting in new performance-based navigation routes. Combined with improvements in air traffic management, there will be more free-routing trajectories.

In addition, increase in demand and pressure on available space will also see a need to review our existing structures to identify more regularly where the pressure will be, and alleviation options.

Integration of new technologies

New Zealand will see an expansion in remotely piloted aircraft, which will need accommodating within the airspace system. Commercial interests are also starting to develop an expanded space industry, and more rocket launch sites are being established around the world.

These technologies have increased requests to use airspace that was previously not required, thus adding greater complexity to the design task.

Aircraft equipage

With the introduction of new technologies enabling better navigation guidance and surveillance of aircraft, only suitably equipped aircraft will be able to enter controlled airspace to meet air traffic management requirements.

While the changes in navigation and air traffic management are likely to result in smaller controlled areas, provision for aspects of the general aviation community may need to be included to enable some on-going access.

Stakeholder engagement

Traditionally, airspace design has developed in a piecemeal way as different users request changes to

8 Some unique airspace designations that may be used within New Zealand are not supported by ICAO regulatory material (SARPs), and in some instances, their design and implementation can create unintended consequences.

airspace at different times. The current approach to airspace design requires a more holistic view. This will require all users of airspace to work together to agree on the most efficient use of that space. Collaboration and partnership is essential to this approach.

Plan for airspace design

Stage 1 2014-2015 Review existing designations, and develop methodology and triggers for future reviews.
Stage 2 2016-2018 Full review of New Zealand airspace.
Stage 3 2019-2023 Ongoing review of airspace impacts from new technologies.

Objectives

- Review existing designations to determine what changes or additions are necessary, including consideration of other ICAO airspace designations.
- Airspace reviews to become more demand-driven. Develop triggers and methodology for airspace reviews to take into account milestones and significant changes in activity:
  - Encouragement of collaborative airspace user forums to identify and agree airspace changes.
  - Base any reviews on a clear understanding of future needs – including specific operator requirements, traffic volumes and types of aircraft, such as remotely piloted aircraft and rockets.
  - Ensure protection of nationally important airspace – including for security and defence, environmental protection and economic importance.
  - Enable transit across the length of New Zealand domestic airspace for VFR traffic.
  - Be coordinated with other jurisdictions.
  - Ensure that all airspace redesign is undertaken in a consultative way. There should be general guidance as to who should be included in the process, as well as how the process should be managed.
  - Disseminate information and training to operators about the changed routes and airspace structures.
- Reassess provisions relating to transponder requirements – including an assessment of whether uncontrolled airspace should be transponder mandatory, if it is deemed necessary for enhanced safety, without the need for special use airspace to be established.
- Consider what, if any, variations to airspace rules and procedures could be applicable to cover aircraft emergencies and civil emergencies.

Principles

- Airspace boundary definition methods should be kept as few and as simple as possible. The primary driver of the placement of boundaries should be utility, rather than convenience, such as aircraft performance (e.g. the rate of climb/descent), adjacent aerodromes, airspace users etc.
- Maximise benefits of new navigation, communication, information and surveillance technologies and operating techniques.
- Address changing environmental impacts (noise, emissions) and the likely reaction to this.
- Controlled airspace should be minimised and simplified where possible.

Airspace design actions

Key Objectives.	Stage 1 2014-2015 *Review existing designations, and develop methodology and triggers for future reviews.*	Stage 2 2016-2018 *Full review of New Zealand airspace.*	Stage 3 2019-2023 *Ongoing review of airspace impacts from new technologies.*
Review existing designations.	Review existing designations to determine what, if any, changes or additions may be necessary, including consideration of other ICAO airspace designations.		Review existing designations to determine what, if any, changes or additions may be necessary, including consideration of other ICAO airspace designations.
Develop triggers and methodology for airspace reviews to take into account milestones and significant changes in activity.	Airspace Collaborative Forums formed. Develop triggers and methodology for future airspace reviews. Define the methodology in guidance documents, including consultation requirements.	Full review of New Zealand airspace based on the methodology.	
Reassess provisions relating to transponder requirements.		With the Introduction of ADS-B, review transponder mandatory airspace requirements.	
Consider whether there should be any variations to airspace rules and procedures.	Review airspace provisions relating to emergencies and civil emergencies–taking changes in navigation, surveillance and air traffic management changes into account.		

Aerodromes
Increasing capacity

Introduction

Aerodromes have come a long way since the use of grass paddocks. The introduction of paved runways, runway lighting, commercial passenger terminals and approach slope lighting have progressively improved services offered by airports. During the 1960s, airport construction boomed with the increase in jet aircraft traffic. Runways were extended and jet bridge systems were added to airport terminals.

Aerodrome infrastructure can be a limiting factor when attempting to improve traffic flows and improve system capacity. This ever-increasing pressure on aerodrome infrastructure means that airport management is driven by a collaborative process of master planning, linking in with both airspace management requirements and land-use management planning to ensure a safe and efficient service for passengers and operators.

International developments

Worldwide, management of traffic flow at aerodromes is being incorporated into a harmonised and integrated approach to air traffic management. In addition, improved aerodrome design and management activities, including coordination and collaboration between Air Traffic Service providers, vehicle operators and aircraft operators can have an important impact on safety, efficiency and capacity at aerodromes. Today's aerodrome operator needs to consider a raft of factors, including:

- Anticipated number and frequency of movements on the runway and in surrounding airspace during peak periods (linking in with airspace management). Enhancing the performance of runway operations begins with the establishment of runway capacity benchmarks. This is usually defined as the maximum number of movements that can be handled per hour in certain weather conditions and for certain operations.
- The mode of runway operation i.e. mixed, independent, dependent or segregated parallel operations.
- The characteristics of the aircraft that the aerodrome is intending to serve, both now and in the foreseeable future.
- The geometric layout of the airport and its taxiway system to reduce runway occupancy times and provide resilience of operations in the event of maintenance or unserviceability.
- Appropriate use and siting of visual aids, power reticulation and secondary power supplies.
- The siting of the air traffic control tower so that it adequately meets its primary purpose and does not impede future modes of operation or approach categories.
- The lowest meteorological minima intended for each runway.
- The ambient light conditions intended for the operation of aircraft.
- The ground infrastructure including lighting, taxiways, runway and surface guidance to improve safety and to maximise aerodrome capacity in all weather conditions.
- All activities on the manoeuvring area or apron, which have a direct impact upon ATM. Terminal capacity also has an indirect impact upon the ATM system, in that the facilities provided can influence

the aircraft turnaround process.

- Development of security measures to deal with increasing threats.
- Increasing need to manage environmental issues, including aircraft noise, wildlife management and impacts of aerodrome expansion.

ICAO has recognised the need for improved flow and collaborative planning to integrate aerodrome management into airspace management in two of its ASBU elements in the Global Air Navigation Plan.

The need for integration with the whole system will become more important, with future network-wide air traffic management moving towards flight approvals at the time of departure (meaning that aircraft are held at the departure gate rather than in the air at the arrival point). This means that future management of aerodromes will need to link into en-route and arrival air traffic management systems, and development of databases and data-link systems also include management of air traffic at source.

Table 7: ICAO block upgrades related to aerodromes

	Block 0	Block 1	Block 2	Block 3
Safety and efficiency of surface operations (SURF).	Airport surface surveillance for service providers.	Enhanced safety of surface operations and enhanced vision systems – airport surface surveillance for service providers and flight crews with safety logic, cockpit moving map displays and visual systems for taxi operations.	Optimised surface routing and safety benefits – taxi routing and guidance evolving to trajectory-based with ground/ cockpit monitoring and data-link delivery of clearances and information – cockpit synthetic visualisation systems.	
Improved airport operations through airport collaborative decision-making (ACDM).	Improved airport operations through collaborative decision-making (CDM) –airport operational improvements through he way operational partners at airports work together.	Optimised airport operations through airport CDM–airport operational improvements through the way operational partners at airports work together.		

Status of New Zealand aerodrome management

Airports are critical components of New Zealand's national economic infrastructure. They support trade and tourism and help to drive growth across the economy. Continual investment in, and upgrading of, the aviation infrastructure at airports is needed to continue to drive national productivity and economic performance. This has been acknowledged in the National Infrastructure Plan (2011).

New Zealand airport operators are a mix of privately and publicly owned companies, local authorities and central government agencies focused on the operation of their respective airports. They are required by statute to operate as commercial undertakings. New Zealand is well advanced in collaboration with air traffic managers to ensure the most efficient use of aerodromes.

Operating aerodromes include:

- Three main international airports (identified by the ICAO Asia-Pacific Regional Air Navigation Plan) Auckland, Christchurch and Wellington. These also serve as domestic hubs for the northern, central and southern parts of the country, with regular services to regional areas:
    - Auckland Airport is the main long-haul international airport, with the second highest category of precision Instrument Landing System (ILS), Category IIIB.
    - Christchurch Airport also services long-haul international operations, as well as providing an international base for flights to and from Antarctica. It has a Category I ILS.
    - Wellington Airport's international traffic is predominately trans-Tasman, together with some seasonal routes to the Pacific Islands. It has a Category I ILS.
- Five airports have had, or currently have, trans-

Tasman services:
  - Queenstown
  - Rotorua
  - Dunedin
  - Palmerston North
  - Hamilton.
- Twelve regional airports currently have a Part 121 air transport operation and a number of smaller regional airports have a Part 125 air transport operation. (Sept 2013).
- One military airbase (Ohakea) is served with a Category I ILS and may be used with prior approval as an alternate airport for international operations.
- Around 150 published aerodromes and heliports. Christchurch Airport has two runways able to handle long-haul international aircraft, although the secondary runway is not served by an ILS and is not necessarily acceptable for some international aircraft.

Collaborative Arrivals Manager (CAM), developed by ACNZ, is an Airways air traffic management system that has been implemented at capacity-constrained Auckland and Wellington airports.

It will be further enhanced through the implementation of Arrivals Manager (AMAN) and Departures Manager (DMAN). A further enhancement embodying both arrivals and departure processes is the development of an Airport Collaborative Decision Making tool[9]. While network-wide in application, its primary use will, like CAM, be focused only on capacity-constrained airports.

Many aerodromes in New Zealand have strategic master plans. These plans set out a concept of operations that provides the basis for planning future infrastructure and services.

Challenges for New Zealand

On the whole, major airports in New Zealand are in good shape for the future, with good air traffic management systems and appropriate infrastructure. However there are some areas where further action could be considered.

Critical infrastructure aerodromes

While New Zealand is well-served by the national distribution of airports, air transport activity (aircraft movements, passenger numbers and freight volumes) is relatively concentrated. Auckland, Christchurch and Wellington airports have significant roles in international connections, as well as being hubs for flights to regional centres, and can be considered critical to the air transport system.

Critical infrastructure aerodromes currently have some acknowledgement in local land-use planning (e.g. noise sensitive areas), but limited acknowledgement at a national level. These airports are private companies (in some cases, local authorities or government maintains a shareholding). This reduces the levers that Government has available to manage the national interest in aerodrome infrastructure.

Movement area capacity

While runway and taxiway throughput is usually efficient in good weather, significant delays are often experienced in poor weather conditions at many airports. Better linkages across the system are required to manage these situations and avoid holding aircraft in the air. Monitoring of aircraft movements at individual airports is important to enable analysis supporting appropriate airspace and infrastructure planning measures so that capacity is not artificially restrained.

Network capacity

The changes in the airspace and air navigation system signalled elsewhere in this Plan will create greater efficiencies (and therefore potentially more aircraft in the sky at any one time). It is important to ensure that the benefits that accrue from increased efficiency in the air are not negated by lack of capacity on the ground across New Zealand's network of aerodromes.

Contingency

The critical connection with other parts of the air traffic management system means that capacity planning will also need to take into account disruption to the overall air traffic management system.

Linkages

Apart from the main international airports, aerodrome operators as a whole have not been actively involved in collaborative decision-making with the air traffic management (ATM) system. There are opportunities for awareness of airspace implications and their aerodromes' roles in the national air traffic management system to be raised.

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9. The concept of "Airport Collaborative Decision Making" brings all the airport partners together to work in a more proactive and transparent way to maximise the use of the available airport infrastructure and resources. With improved information sharing and agreed working procedures, all partners benefit from increased predictability of operations and more situational awareness.

While master planning is in place for many aerodromes, more work may be required to create better linkages beyond the aerodrome, in a network-style approach.

A challenge for planners is integrating the needs of all users and people affected by planning decisions. Airport operators are part of a collaborative partnership incorporating the regulator, air traffic service provider and aircraft operators in determining future capacity requirements. A feature of many of New Zealand's aerodromes that will need to be addressed is the range of different aircraft types and operations that use the aerodrome facilities.

Data exchange

Predictability in aircraft movements is a challenge faced by aerodromes, particularly during poor weather events. Local collaborative decision-making processes are needed that will lead to sharing of flight scheduling data. This will enable all participants to improve their awareness of aircraft status throughout the turnaround process. This will allow more efficient ground handling, reduction in delays and greater predictability of schedules, which in turn will lead to greater capacity.

Land-use planning

The Resource Management Act 1991 requires that district plans are reviewed at intervals of no more than 10 years. In addition, designations are a commonly used tool by airports (especially Auckland, Wellington and Christchurch) for managing land use around airports.

It is therefore important that all participants in the system, including aerodrome operators, the wider aviation sector and local authorities are proactive and ensure that the growth in aerodrome capacity is appropriately integrated within these plans. Land-use controls need to include restrictions on incompatible use or activities, potential obstacles or hazards that could impact the safe and efficient operation of aircraft. Appropriate objectives, policies and rules in both regional and district plans or airport designations are required.

The main components to be considered are:

- Protection of obstacle limitation surfaces.
- Protection of new and modified aircraft arrival and departure paths, determined in collaboration with airline operators and air traffic service providers.
- Integration with airspace designation and planning.
- Noise emissions, including management of the effects of aviation activities on communities.
- Wildlife hazard management strategies in relation to the airport environs and flight arrival and departure paths.

Objectives

- Master plans for aerodromes should include the following features where applicable:
  - Increase aerodrome capacity using collaborative decision-making.
  - Take into account the need for integration with other aspects of the ATM system, land-side operations and interaction with land-use planning.
  - Achieve all-weather throughput at as close to the levels of visual throughput as possible.
  - Improve the predictability of movements based on shared information.
  - Specify the infrastructure needed (surveillance tools, visual aids, approach types, lighting and geometry required), depending on the demands and needs of the system.
  - Ensure that appropriate contingency plans are in place that reflect a network management approach.
- Review terminal and airfield design/geometry at capacity-constrained airports.
  - Identify constraints to reduced runway occupancy times or aircraft movement capacity.
  - Assess the need for capacity enhancement at capacity-constrained airports where required to meet forecast industry capacity demands.
- Ensure that New Zealand's network of airports can support the changes occurring in the airspace and air navigation system.
  - Review implications for New Zealand's network of aerodromes flowing from changes in the airspace and air navigation system.
  - Develop policy and guidance to address implications if required.
  - Review critical infrastructure and systems to identify areas where further contingency measures are required to provide an industry-agreed level of resilience.
- Establish formalised airport collaborative decision-making forums for each aerodrome.
- Develop guidance for airport operators and councils on managing environmental effects related to aerodromes (including, but not limited to, noise).

Principles

- Collaboration with aviation partners.
- Timely provision of sufficient aerodrome capacity in a range of weather conditions.
- Compatible land-use planning for surrounding land.
- Resilience in the provision of aerodrome services.

Aerodrome actions

Key Objectives	Stage 1 2014-2015 *Establish collaborative decision-making forums and ensure effective contingency plans are in place.*	Stage 2 2016-2018 *Ensure that New Zealand's network of airports can support the changes occurring in the airspace and air navigation system.*	Stage 3 2019-2023 *All aerodrome master plans should take into account the objectives and actions set out in the National Airspace and Navigation Plan.*
Aerodrome master plans.		All aerodrome master plans should take into account the matters and objectives set out in this Plan.	
Aerodrome collaborative decision-making forums.	Aerodrome collaborative decision-making forums established.	All international aerodromes to establish formal collaborative decision-making.	
Capacity-constrained airports.	Review terminal and airfield design/ geometry • Identify constraints to reduced runway occupancy times or aircraft movement capacity. • Establish the need for capacity enhancement to forecast industry capacity demands.		
Ensure that New Zealand's network of airports can support the changes occurring in the airspace and air navigation system.	Identify and monitor key airport metrics. Review aerodrome contingency plans to ensure an industry-agreed level of resilience.	Review implications for New Zealand's network of aerodromes flowing from changes in the airspace and air navigation system. Develop policy and guidance to address implications if required.	
Guidelines for environmental management.	Develop guidelines for aerodrome operators and councils on environmental management issues (including noise).		

Meteorological Services
Integrating weather information

Introduction

Meteorological services, including warnings, briefings, forecasts, observations and delivery systems, are an essential component of national and international aviation operations, contributing to safety and efficiency.

Communication and integration of meteorological information into air traffic management and navigation systems is essential for the implementation of a globally interoperable, seamless air traffic management system.

International developments

Internationally, changes to the provision of meteorological information will be based on the integration of meteorological and air traffic management information to support operational decision-making. This direction was confirmed at the ICAO 12th Air Navigation Conference in November 2012, and is outlined in the Global Air Navigation Plan (Table 8).

The conference noted that meteorological information was an integral component of the future system-wide information management (SWIM) environment, alongside aeronautical information, flight and flow information and other information sources. This would enhance the safety and the efficiency of the global ATM system.

The concepts for global air traffic management (ATM) and performance-based navigation (PBN) are well documented in:

- PBN concept in ICAO Doc 9613 *Performance-based Navigation (PBN) Manual.*
- Global ATM concept in ICAO Doc 9854 *Global Air Traffic Management Operational Concept.*
- ICAO Doc 9882 *Manual on Air Traffic Management System Requirements.*
- Air Traffic Management Requirements Performance Panel (ATMRPP) document *Flight and Flow Information for a Collaborative Environment* (FF-ICE).

However, all of the above documents currently only mention or reference weather (meteorological services) in general terms. The documents do not as yet specify the particular meteorological services required for global air traffic management and to support performance-based navigation.

Despite the lack of international clarity, meteorological information is already being integrated into flight management systems and is expected to be factored into ATM Decision Support Tools (DSTs) and airline Safety Risk Assessments (SRAs) to mitigate risk and support safe and efficient flight operations, especially where airspace and aerodromes are congested or capacity is constrained.

This will enable best-trajectory services and operations by formulating the most efficient air traffic routing and flight profile solutions that continuously account for dynamic meteorological conditions and phenomena. DSTs and SRAs should allow end users to make structured decisions based on current and predicted meteorological conditions.

DSTs are envisaged as software applications used to automate meteorological impact evaluations and ATC operator and user response. DSTs will fuse meteorological information with other relevant information, such as aeronautical, flight planning and operations management information, as well as engineering data, to support better information-based decision-making.

Meteorological services for general aviation will be increasingly shaped by International developments. New meteorological requirements that are adopted for airlines and ATM may flow through to flight training, smaller commercial operators and the recreational general aviation sector. However, general aviation may require current legacy products to continue in the short term.

It is also expected that users will require more use of probabilistic forecasts in the future to enable decisions formerly predicated on agreed pre-determined thresholds.

Table 8: ICAO block upgrades related to meteorology

	Block 0	Block 1	Block 2	Block 3
AMET	Meteorological information supporting enhanced operational efficiency and safety. Aerodrome warnings to give concise information. Forecasts provided by world area forecast centres, volcanic ash advisory centres and tropical cyclone advisory centres. Supports flexible airspace management, improved situational awareness and collaborative decision-making and dynamically optimised flight trajectory planning.	Enhanced operational decisions through integrated meteorological information (planning and near-term service).		Enhanced operational decisions through integrated meteorological information (near-term and intermediate service).

Status of New Zealand meteorological services

Annex 3 to the 1944 Chicago Convention on International Civil Aviation (the Convention–administered by International Civil Aviation Organization–ICAO) defines the basic meteorological services required for international air navigation. These services are designed to contribute towards the goals of safety, regularity and efficiency of international aviation.

Annex 15 to the Convention defines the subset of meteorological services required for the state aeronautical information service to ensure the flow of information and data necessary for the safety, regularity and efficiency of international air navigation.

The CAA is designated by the Minister of Transport as the National Meteorological Authority. It should be noted that this responsibility is for delivery of Annex 3 requirements i.e. there is currently no legal obligation to provide domestic weather information.

The CAA contracts the Meteorological Service of New Zealand Limited (MetService) to meet operational Annex 3 requirements for international aviation.

MetService is certificated under Civil Aviation Rule Part 174 and provides five of the six service categories (it does not provide a climatology service). Volcanic Ash Advisory Centre operations are provided through MetService. It provides domestic weather information under this certification and recovers costs through user charges.

Airways is certificated under Rule Part 174 to provide meteorological reporting and to disseminate meteorological information. Airways is also certified under Part 174 to provide the current aeronautical fixed telecommunications system for the distribution of meteorological information to the aviation system.

Table 9: Existing meteorological plans

Timeframe	Plans for Metservice	Delivery Mechanisms
2013-2018	Implementation of ICAO AMD 76 wef 14 Nov 2013. Implementation of ICAO AMD 77 wef 14 Nov 2016. Deliver text and graphics in XML (Extensible Mark-up Language) and GML (Geographic Markup Language) starting in 2014. Test and plan for implementation of conceptual and exchange models and associated formats that are highly applicable to ICAO standards, and in particular ICAO Annex 3 starting in 2014. (The models should include conceptual and exchange representations of AIRMET, AIREP, AMDAR, CCFP, G-AIRMET, SIGMET, METAR, PIREP, VAA, MDCR, and TAF. They should also include representations for weather information types such as wind shear, contours, gust fronts, motion vectors, grids, points, trajectories, profiles, swaths, and sections).	Self-managed internet-based systems. Direct feeds to airline flight operation centres. FTP server. Webpages. Webcams. Email. Faxing. AFTN/AMHS. Application agnostic delivery channels for tablet devices and smart phones.

Challenges for New Zealand

Funding and resourcing

Internationally, some of the concepts being implemented in major regional air traffic management modernisation programmes require a significant investment in both resources and technology, and will be difficult for some states of the Asia-Pacific region to implement. The use of older text format messages by some states in a progressively digital environment is likely to require duplication of delivery and processing systems for meteorological information in the short term.

A phased, gradual approach to technology uptake and its operational implementation will be required. Users of meteorological information will vary in their ability to transition to new meteorological products and technologies, and consideration should be given to the extent to which legacy systems may need to be retained to support the transition, as well as to avoid reliance on a single technology in the longer term.

The needs of users in the broader operating environment outside New Zealand airspace should be considered in order to achieve, where practicable, a closer alignment with ICAO's vision of an integrated, harmonised and globally interoperable air traffic management system.

Regionalisation of hazardous weather information and data, and possibly the production of aerodrome meteorological forecast information, is highly likely. Under such a regime, New Zealand will probably need to take on regional responsibilities for a large part of the South Pacific. This will have resource and cost implications.

There is currently no government funding for the provision of meteorological services for aviation in New Zealand. In the near term, the cost of providing services will continue to be recovered on a commercial basis under the state-owned enterprise legislation and, where appropriate, charging guidelines issued by ICAO. Alternative means of recovering costs of meteorological services from the aviation sector will continue to be assessed on the basis of utility, equity and responsiveness.

General aviation access to weather data

Concerns have been raised about the cost of access to meteorological data. During consultation on this Plan, some concerns were raised about the cost of access to, and use of meteorological information provided by the certificated supplier. Anecdotal information suggesting some GA users are not accessing or correctly using meteorological information reflects a clear safety risk in this regard.

ICAO meteorological specifications

ICAO, through its various working groups, has not yet specified the meteorological services required for global aeronautical information services and air traffic management; these services are currently at a conceptual stage. On the other hand, ICAO has documented, in detail, the concepts for global aeronautical information services, air traffic management and performance-based navigation. Although many of these documents mention or reference weather (meteorological services) in general terms, they do not yet specify the meteorological services required.

Conflicting products

Real-time meteorological data streams could be provided, mitigating the risk of potentially conflicting and perishable meteorological products. Such a network-enabled provision of meteorological information would support common situational awareness amongst air traffic managers and operators.

Sources of weather data

In New Zealand, most current weather support to aeronautical information services, air traffic managers and other aviation users is provided for use by individuals such as pilots, air traffic controllers, traffic managers and dispatchers. Transitioning from this approach has several challenges:

- Some weather products do not have the maturity required for direct insertion or integration without interpretation, nor are they currently able to be translated into impact information.
- Rules for interpretation and use of weather data are generally based on the experience of the user and/or the level of technology available.
- Air traffic management decisions based upon current meteorological information and products are inconsistent from user to user.

Implementation risks

Implementation risks are associated with the following:

- Matching the meteorological capabilities of well-equipped airline flight operation centres particularly the ability to transmit data to and from cockpits, with those of less well-equipped airline flight operational centres and other users.
- The capability of airline flight operation centres and users to receive and use updated meteorological data in-flight to accommodate flexi-route operations.
- Continued use of older text format messages by less well-equipped airline flight operation centres and users in a progressively digital environment will probably require some duplication of delivery and processing systems for meteorological information.

Legislative mandate

There is currently no legislated requirement for any New Zealand organisation to provide meteorological services for domestic aviation. However, there are requirements for air operations under Civil Aviation Rule Parts 121, 125 and 135 for meteorological information to be used for a flight sector originating within New Zealand provided by a holder of a Part 174 aviation meteorological service organisation certificate.

The existing designation of the CAA as the Meteorological Authority is enacted through Ministerial delegation of this responsibility from the Chicago Convention, and only applies to international aviation.

Plan for meteorology

Stage 1 2014-2015	Develop IWXXM format for weather.
Stage 2 2016-2018	Integration of weather data with aeronautical information.
Stage 3 2019-2023	Weather into cockpit, real-time.

Objectives

- Meteorological information products to be in extensible markup language (XML) or geographic markup language (GML) formats.
- Develop information exchange standards to ensure interoperability within New Zealand and the Asia-Pacific region that are linked with other aviation data domains.
- Replace the use of individual meteorological products with network-enabled consistent meteorological information supporting common situational awareness. This approach should cover the full set of products.
- Integrate meteorological information into:
  - Aircraft operation systems, including glass cockpits, electronic flight bags and portable carry-on devices such as iPads, as well as operator safety risk assessments, air traffic management and aeronautical information service decision support systems.
  - Aeronautical information management data, aiming for meteorological information streaming to flight operation centres, air traffic managers, aeronautical information services, and aircraft cockpits.
- Decision-support tools provided to air traffic managers to deal with meteorological information and translate it into constraints and impacts on air traffic management and performance-based navigation.
- Greater use of probabilistic forecasts, to enable users to make decisions based on their own pre-determined thresholds.

- Develop sector-wide policy on the provision of, and access to, aeronautical meteorological information, in line with the technical changes and developments set out in this Plan.

Principles

- Future meteorological and air traffic management systems should promote the sharing of real-time meteorological information.
- All interpretation and translations of meteorological information will need to be automated and objective.
- Keep pace and maintain alignment with international development.
- Characterisation of meteorological forecast uncertainty is a key precept.
- Intensities and rates of forecast and observed meteorological conditions will need to be expressed as indexed values that can be calibrated according to aircraft type, rather than characterised as light, moderate or severe without regard to the aircraft type.
- Future meteorological support provided for New Zealand aviation should be designed to minimise the impact of weather on the air transport system within New Zealand's areas of responsibility.
- Worldwide collaboration is key to effective and integrated meteorological services.

Meteorology actions

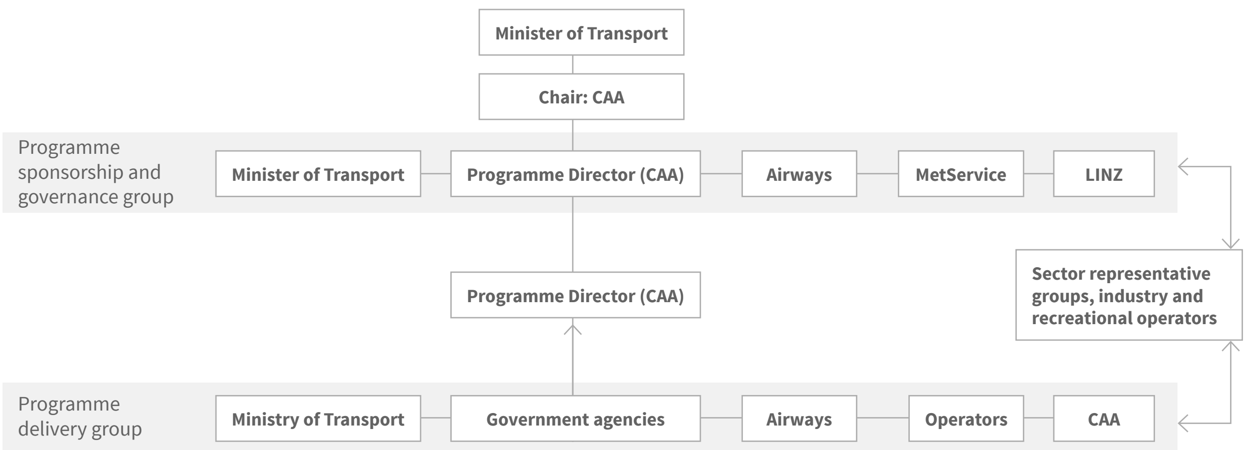
Key Objectives	Stage 1 2014-2015 *Establish collaborative decision-making forums and ensure effective contingency plans are in place.*	Stage 2 2016-2018 *Ensure that New Zealand's network of airports can support the changes occurring in the airspace and air navigation system.*	Stage 3 2019-2023 *All aerodrome master plans should take into account the objectives and actions set out in the National Airspace and Navigation Plan.*
National observation data network automation and optimisation.	METAR AUTO instrumentation implemented at all domestic, military and international aerodromes.	Radar imagery from full network available to ATM centres and ATC tower controllers.	
Implementation of GRIB2 data feed from WAFC.	All users (ANSPs and aircraft operators) provided with operational GRIB2 data.		
Establishment of graphical products.	Implementation of graphical SIGMET (by mid-2014).		
Development of XML/GML versions of MET data.	Continuing support for the development and implementation of digital exchange of MET information (consistent with IWXXM).		
Hazardous weather products.	Development and implementation of HAZWX products.		
Data access and exchange.	User-managed access protocols and systems to defined data sets established.	Facilities for data-centric exchange of information in place.	Data-centric exchange of information commonplace.
ATM decision support tool inputs.	Clear requirements provided by operators, AIS and ATM for new meteorological data and products.	New decision support tool input data products defined and coded.	New decision support tool input data products widely available.
Policy and regulatory change.	Develop a sector-wide policy on the provision of, and access to, aeronautical meteorological information, in line with the technical changes and developments set out in this Plan. Review of Civil Aviation Act meteorological provisions completed.	Contingent change of responsibilities, governance and funding structures.	

Implementing this plan

The success of this Plan and the realisation of the safety, economic and environmental benefits of the new technologies signalled is dependent on effective communication and coordination across a range of different agencies and the aviation community.

An implementation programme will be led and managed by the Civil Aviation Authority and will include a range of agencies, each with leadership roles in specific projects that sit under the Plan. Opportunities for ongoing consultation and involvement will be provided throughout the implementation programme. Funding will be provided initially from agency baseline and thereafter through normal budget and funding review processes. For further information about the implementation programme and to find out about opportunities to be involved, go to www.nss.govt.nz.

National Airspace and Air Navigation Implementation Programme Governance



Airways Corporation is responsible for implementing changes to air traffic management surveillance and navigation systems and processes.

The Ministry of Transport is the Government's principal transport adviser. It helps the Government give effect to its policy by supporting the development of legislation, regulations and rules. The Ministry is responsible for providing advice to the Government on policy and regulatory issues arising from the implementation of New Southern Sky.

MetService is responsible for the development and provision of weather information for the New Southern Sky air traffic management and navigation systems.

ANALYSIS

Consultation on this Plan

Development of this Plan was assisted by a large number of aviation community representatives and agencies. Core information in each chapter was prepared by a series of cross-industry task groups. An aviation community peer review group[10] assisted with the collation of the Plan and final proposals. They have indicated their agreement on the format final proposals.

Wider consultation with the aviation community was undertaken between October 2013 and February 2014, with emails sent out to all operators, organisations and aircraft owners; a series of workshops held around New Zealand; and articles in the Civil Aviation Authority safety magazine and website. See https://www.caa.govt.nz/naanp/naanp_home.htm for a detailed summary of submisA sions.

Consultation indicated wide support for the general proposals in the Plan, with most points focused on proposals surrounding the introduction of ADS-B. Key points during this process included:

1. Effects of proposals on the general aviation community (including cost and fairness of cost distribution, standards required, practicality, availability of engineers, the need to provide for transit across the country and the need to provide for discrete operations).
2. Support for retaining contingency systems for both air navigation and surveillance.
3. Lack of support for mandatory ADS-B requirements outside controlled airspace.
4. Wide support for decreasing controlled airspace and the development of airspace collaborative forums.
5. The need for airports and councils to work together to manage noise and environmental issues.
6. Wide support for integrated aeronautical and meteorological information management.
7. Concerns around general aviation access to meteorological information.
8. The need for education and communication on implementation to be given priority.
9. The need for ongoing consultation and involvement in implementation.
10. More references to general aviation and how different groups will be affected.

The Plan has been amended to take account of these concerns.

Economic analysis

An independent report by Castalia Strategic Advisors was commissioned to assess the economic implications of the proposals in the draft Plan[11]. Castalia estimated that the net benefit of all the changes encompassed by the Plan is $1.985 billion. A number of these benefits are market driven, however, the overall net benefit attributable to the Plan is estimated at $178 million[12]. This benefit can be attributed to the regulatory change and coordination required to allow and enable productivity gains in the aviation sector. A peer review of this document by Infometrics[13] noted that the majority of the benefits identified stem from the performance-based navigation actions. However, even when these actions are not included in the calculations, the overall net benefit is positive. For example, the benefits from ADS-B implementation alone are $9 million.

Summary of costs and benefits

Costs	Total value of all changes	Attributable to the plan
Total costs	$37,019,814	$1,516,024
Total direct benefits	$1,466,365,636	$130,534,989
Total indirect benefits	$556,261,998	$49,312,531
Total benefits	$2,022,627,634	$179,847,520
Net benefit	$1,985,607,820	$178,331,496

10 Including representatives from key aviation organisations including, Airways, Air New Zealand, the Board of Airline Representatives, Aviation New Zealand, the Aviation Federation, the Aircraft Pilot and Owners Association, the Aviation Community Advisory Group, the Airports Association, the Airline Pilots Association, the New Zealand Defence Force and MetService.

11 The full Castalia report can be found at https://www.caa.govt.nz/naanp/naanp_home.htm.

12 Net Present Value, 21-year timeframe with an 8 percent discount rate.

13 Review of Economic Analysis of National Airspace and Air Navigation Plan for the Civil Aviation Authority March 2014.

The figures provided are conservative; for example, they do not include any projected growth of the aviation industry over the next 20 years, nor do they attempt to estimate the value of a number of the elements that cannot be easily quantified. This conservative estimate nevertheless clearly demonstrates that the overall net benefit that can be attributed to the Plan is significant. Any delay in implementation will result in high cost.

Castalia identified that different sectors benefit at different levels. The largest net benefits will accrue to the operators and users of larger airlines. Implications for smaller general aviation operators will depend on individual circumstance (current aircraft equipage, whether they use controlled airspace etc). A research study[14] undertaken by the Civil Aviation Authority, which sampled 1000 of the 5800 aircraft records on file, indicates that while most larger airlines are already equipped with appropriate equipment, less than 5% of the general aviation sector is already equipped with a Mode S transponder that can be used for ADS-B surveillance. Forty percent of general aviation aircraft are equipped with a GNSS input, although standards vary. It is not known how many of the aircraft surveyed fly in controlled airspace.

To accommodate concerns around cost for the participants who are not yet equipped or who may need to upgrade, the Plan contains an action item to develop policy to smooth transition for the general aviation sector.

Risk assessment

Castalia also undertook a qualitative assessment of the risks that may arise from the proposed changes. Key risks include:

- Risk to benefits due to changing aircraft routes. While the overall environmental impact of the Plan is likely to be positive, due to reduced carbon emissions and less total noise emissions due to shorter flight paths, changing noise patterns due to changing flight paths could lead to resource management issues on the ground. Some people may notice less noise, while others may notice more. The Plan contains provision for more guidance for airport owners and councils on managing environmental affects at aerodromes.
- Greater reliance on satellite technologies. Increasing reliance on one system may lower resilience and increases risk in the event of failure. The Plan provides for contingency systems for both navigation and surveillance to ensure that all aircraft can return to the ground safely and continuity of service can be maintained on the main trunk routes. Castalia has noted that this means that infrastructure costs will not be significantly lowered on a net basis.
- Capacity to upgrade and retrofit aircraft. The capacity of aircraft owners and engineers to undertake upgrades, due to cost, practicality, or knowledge is a risk. The mitigating actions set out in the Plan are to signal changes in advance and to avoid regulatory shock from unpredictable decisions. Further policy work will be undertaken on options to smooth transition, particularly to the new ADS-B environment.
- Human response to new technology. This Plan signals significant changes in technology – these changes can lead to human error and therefore increased safety risks during transition. The Plan includes a heavy focus on training and education to assist pilots and engineers to make the transition.
- Future change. New technology may be developed in the future that affect the proposals in this Plan. The Plan has been prepared on the basis of existing knowledge. It follows international best practice and guidance. It also provides for regular reviews.
- A full assessment of the risks, including potential mitigation options is set out in Castalia's report.

14 https://www.caa.govt.nz/naanp/naanp_home.htm

Civil Aviation Authority of New Zealand.
Asteron Centre, 55 Featherston Street, PO Box 3555,
Wellington, 6140 New Zealand.